

MAR 22 2019

SC DHEC - Bureau of Land & Waste Management

Tetra Tech NUS, Inc. Foster Plaza 7, Suite 200 661 Andersen Drive Pittsburgh, PA 15220-2700 Tel:412.921.7090 Fax:412.921.4040

LETTER OF TRANSMITTAL

TO: Meredith Ar	mick and Jerry Stamps	3		DATE: 03/21/2019		JOB NO.: 112G08005-SE0351
SCDHEC (Sou	ıth Carolina Dept	of Health	and	ATTENTION:		
	ontrol), RCRA Federa	l Facilities Sec	tion			
2600 Bull Street						nd Analysis Plan (Field
Columbia, South	Carolina 29201					Quality Assurance Project e Per- and Polyfluoroalkyl
						r Screening Investigation
						narleston Naval Complex
				(CNC), SC		-
	·-					
WE ARE SENDI	NG YOU [] At	tachment []	Under sep	parate cover via		:
[] Shop drawing	gs [] Prints	[] Plans		[] Samples	[] Specifications
[] Copy of lette	r [] Reports	[] Change	Order	[X] Documents	[X] Compact Disks
COPIES	DATE	NO.			CRIPTIO	
3 (2 for Ms.	03/21/2019		Page ch	anges (Revision 2) to	Final S	SAP and CDs
Amick and 1						
for Mr Stamps)	03/21/2019		Comme	nt response letter	addres	sing SCDHEC follow-on
9	00/21/2013					on 1), including a guide to
				g of pages.	`	,,
				·		
THESE ARE TR	ANSMITTED as check	ced below:				
[V] To	- annuoval	[] Farmour		r	1 40 50	augotod
	r approval	•		-	-	quested
[] For r	review and comment	[] Returnin	g following	g use by us [] Retur	ned after loan to us
REMARKS Sub	mittal on behalf of the	Navy.				
				•••.	** •	
	(NAVFAC PMO East)					
	brook (NAVFAC PMO (NAVFAC PMO East)					
File	,					
				ED Luida KK	': A	
			SIGN	ED AMICA 1/	~~~~	

Linda Klink, PE, PMP Project Manager



Response to DHEC Follow-on Comments dated February 22, 2019
Final Sampling and Analysis Plan for Basewide Per-and Polyflouroalkyl
Substances Groundwater Screening Investigation dated January 2019
Charleston Naval Complex (CNC), Charleston, South Carolina
RECEIVED
SCO 170 022 560

MAR 22 2019

Meredith Amick Engineering Comments

1. DHEC Response to Comment #1:

SC DHEC - Bureau of Land & Waste Management

Additional information (Owner, usage status, analytical data, etc.) should be provided under separate cover for all on base supply wells shown in Appendix E. The CNC Partnering Team will need to determine the appropriate path forward for the wells.

Response: The Navy agrees to provide the requested information. So as not to hold up the subject groundwater sampling effort within the former CNC area, the additional requested information for those wells beyond the former CNC will be provided in the future under separate cover. As a starting point, the Navy agrees to provide the information on all wells within the 1-mile buffer (versus the 3-mile buffer).

2. DHEC Response to Comment #4:

Based on information presented in the follow on report as well as developing EPA guidance regarding PFAS, additional sampling may be needed not only in areas investigated but also unsampled areas identified in this work plan.

Response: Acknowledged. The Navy recognizes that additional sampling may be needed for unsampled areas in the future. The subject SAP provides a broadbrush effort to assess the potential PFAS presence at the former CNC.

3. **DHEC Comment:** Any monitoring wells proposed for installation will need a well installation request and subsequent approval from DHEC prior to installation.

Response: Agree. Note that the SAP focuses on existing well sampling. There is only one new monitoring well and it is to be a hand-driven drive point, and a well installation request is in preparation. However, a separate, subsequent field effort will be needed to install this well while the Navy works out logistics before the temporary well can be installed.

4. If IDW is to be treated for PFAS prior to disposal, please consult with DHEC

03/21/2019

prior to treatment. Additionally, IDW should be sampled for full TCLP in addition to PFAS.

Response: Agree. In addition to the extra PFAS analysis, IDW will be sampled for the conventional full TCLP organics and inorganics. Results from the IDW analysis will be shared with DHEC prior to IDW disposal if PFAS treatment of IDW is needed.

5. Based on a 2/21/19 email Burgio to Amick, several well sampling locations are changing. Please provide discussion and figures from the email as well as update the work plan accordingly. Additionally Figure 10-1 should be updated.

Response: Agree. Several iterations of changes have occurred. The attached table to this comment response letter summarizes the changes and the reason for the changes to selected wells for sampling. (The monitoring well situation is dynamic at the former CNC and a future effort is planned to inventory all the former CNC monitoring wells.) Many well locations have changed, all of the well locations have now been field truthed. Page changes to the final SAP have been prepared, which include:

- Revised Table 10-1 (Site/Facility Ranking and Monitoring Well Locations for PFAS Sampling)
- Revised Figure 10-1 (PFAS Sampling Locations).
- Updated Cover and spine
- six page changes to revise 21 selected sampling locations changed to 19 sampling locations (see explanatory table at end of comment response letter).
 Note that one of these page changes, page 37, also corrects the details of the monitoring well redevelopment.

OWNER INFORMATION, MONITORING WELL LOCATIONS FOR PFAS SAMPLING CHANGES OF MONITORING WELL LOCATIONS FOR SAMPLING – MARCH 2019 FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA

Site Well Grouping (Original)	Site Well Grouping (Revised)	Current Owner of Monitoring Well Location	Zone
H659GW009R	Retain, no change.	U.S. Federal Enclave	Zone F
H017GW006	Retain, no change.		
IN28G35W1	Could not locate in recent survey. Replace with IG11GW005.		Zone
1680GW004	Retain, no change.	U.S. Coast Guard	Zone
I12TEMP1 (new temporary well)	Retain, no change. Sample this new well (not existing well after the Navy works out the logistics.	Charleston County Park and Recreation Commission	Zone
H009GW011R	Retain, no change.	U.S. Federal Enclave	Zone H
FU25GW012	Abandoned. No nearby replacement available for this particular well. Other wells already planned, GGELGW012 and F617GW002 for the most part meet project needs.	Palmetto Railways	Zone F
FGELGW012	Retain, no change.	Commissioner of Public Works Sewer Authority	Zone F
FFDSGW15C	Abandoned. Replace with H196GW002.	Palmetto Railways U.S Federal Enclave	Zone F
E065GW008	Retain, no change. Located in the street south of Building 56. Arrangements will be made to move cars out of the way as necessary.	CMMCLLC	Zone E
E025GW003	Retain, no change.		
E172GW001	Retain, no change. The well is located just outside the door of Building 88 and is covered with scrap. Arrangements will be made to have the scrap moved out of the way by asking someone at the shop to move with forklift.		Zone E
E569GW005	Retain, no change.	Building 177 LLC	Zone E
GF08GW08A	Abandoned. Replace with ProbeTech well.	Palmetto Railways	Zone G
G633GW005	Inaccessible, located under a palm tree. Replace with G633GW001, approximately 15 feet away.	Palmetto Railways	
MW-2R	Retain, no change.	City of North Charleston	Zone C
H009GW023	Abandoned (destroyed). Replace with F617GW002.	U.S. Federal Enclave Clemson University	Zone F
FFDSGW04	Abandoned. Replace with H008GW004.	CNC Redevelopment	Zone C
H009GW014	Difficult to access. Replace with H009GW27D. U.S. Federal Enclave		Zone F
E605GW04R	Abandoned. Replace with E605GW007.	CNC Redevelopment	Zone E
DGDDGW001	Abandoned. No nearby replacement available.	FLSC Properties LLC Palmetto Railways Property	Zone D

OWNER INFORMATION, MONITORING WELL LOCATIONS FOR PFAS SAMPLING CHANGES OF MONITORING WELL LOCATIONS FOR SAMPLING – MARCH 2019 FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA

Site Well Grouping (Original)	Site Well Grouping (Revised)	Current Owner of Monitoring Well Location	Zone
	tes revision. s selected well not changed. s no replacement well is available.		



Naval Facilities Engineering Command BRAC PMO East Philadelphia, Pennsylvania

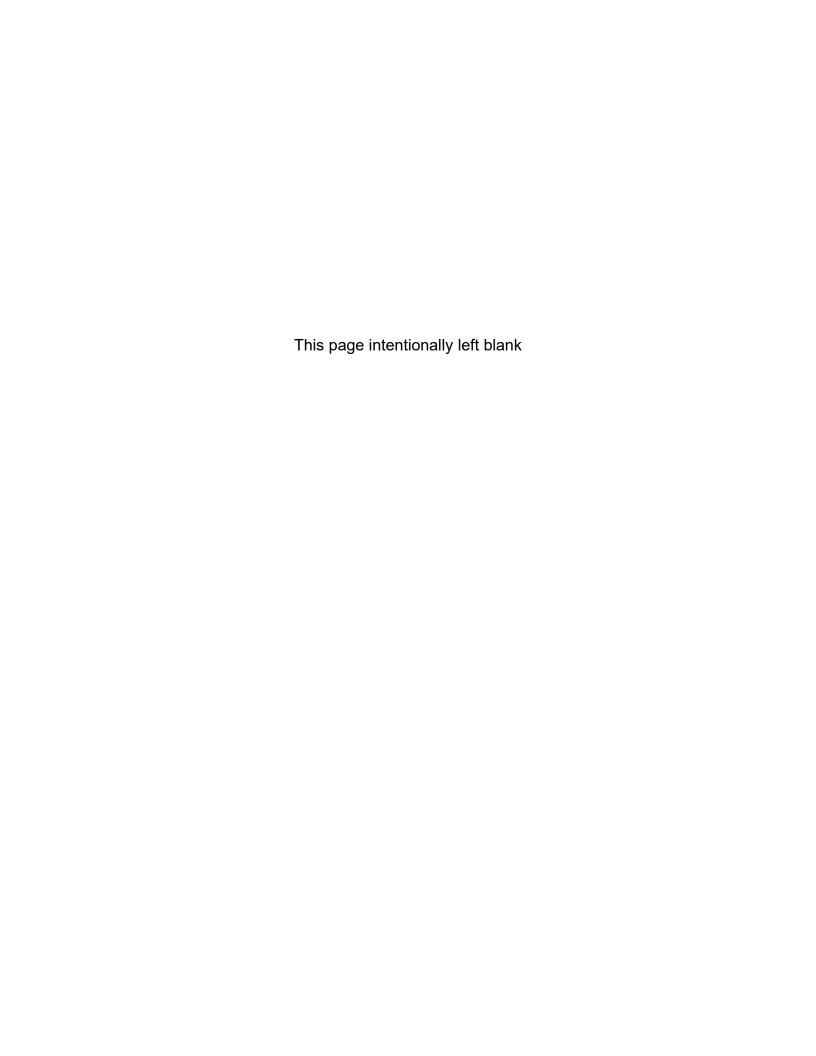
Final

Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) for Basewide Per- and Polyfluoroalkyl Substances Groundwater Screening Investigation

Former Charleston Naval Complex Charleston, South Carolina

March 2019

Distribution Statement A – Approved for public release: distribution unlimited



SAP Worksheet #1: Title and Approval Page

(UFP-QAPP Manual Section 2.1)

Document Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan), Title: Basewide Per- and Polyfluoroalkyl Substances Groundwater Screening Investigation

Naval Facilities Engineering Command (NAVFAC) Base Realignment and Closure **Lead Organization:**

(BRAC) Program Management Office (PMO) East

Preparer's Name and Organizational Affiliation: Tetra Tech

Preparer's Address and Telephone Number:

TETRA TECH rid CLEAR SOLUTIONS Twin Oaks I. Suite 102 5700 Lake Wright Drive Norfolk, Virginia 23502-1860 (757) 461-3768

Preparation Date (Day/Month/Year): 18 January 2018

Investigative Organization's Project Manager: Linda Klink

1/30/19

Revision No: 1

Date: January 18, 2019

Signature/Date

Linda Klink, PE, PMP/Sr. Project Manager/Tetra Tech

Investigative Organization's Project QA

Manager:

J. E. Johnston

1/30/2019

Signature/Date

Tom Johnston, PhD/QA Manager/Tetra Tech

EASTERBROOK.MARK. Digitally signed by CHARLES.1508925537 Date: 2019.02.06 11:19:46 -05'00'

EASTERBROOK.MARK.CHARLES.1508925537

Lead Organization's Project Manager:

Signature/Date

Mark Easterbrook/RPM/NAVFAC BRAC

Lead Organization QA Officer:

(See Next Page for Signature)

Signature/Date

Teresie Walker/NAVFAC Chemist/QA Officer/NAVFAC

Atlantic

Approval Signatures: Approval via separate approval letter

Signature/Date

Meredith Amick, PE/Project Manager/South Carolina Department of Health and Environmental Control

041817/P SE0351 Page 1 of 89

SAP Worksheet #1: Title and Approval Page

(UFP-QAPP Manual Section 2.1)

Document Title:

Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan), Basewide Per- and Polyfluoroalkyl Substances Groundwater Screening Investigation

Lead Organization:

Naval Facilities Engineering Command (NAVFAC) Base Realignment and Closure

(BRAC) Program Management Office (PMO) East

Preparer's Name and Organizational Affiliation: Tetra Tech

Preparer's Address and Telephone Number:

TETRA TECH

complex world CLEAR SOLUTIONS

Twin Oaks I, Suite 102 5700 Lake Wright Drive Norfolk, Virginia 23502-1860 (757) 461-3768

Revision No: 0

Date: MayJune 2018

Preparation Date (Day/Month/Year): 17 May 2018

Investigative Organization's Project Manager:

Signature/Date

Linda Klink, PE, PMP/Sr. Project Manager/Tetra Tech

Investigative Organization's Project QA

Manager:

Signature/Date

Tom Johnston, PhD/QA Manager/Tetra Tech

Lead Organization's Project Manager:

Signature/Date

Mark Easterbrook/RPM/NAVFAC BRAC

70071

WALKER.TERESIE.R.15158 Digitally signed by WALKER.TERESIE.R.1515870071 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USN, cn=WALKER.TERESIE.R.1515870071

Date: 2018.06.29 15:21:52 -04'00'

Lead Organization QA Officer:

Signature/Date

Teresie Walker/NAVFAC Chemist/QA Officer/NAVFAC

Atlantic

Approval Signatures:

Signature/Date

Meredith Amick, PE/Project Manager/South Carolina Department of Health and Environmental Control

EXECUTIVE SUMMARY

Revision No: 2

Date: March 21, 2019

Tetra Tech has prepared this Sampling and Analysis Plan (SAP) to evaluate whether per- and polyfluoroalkyl substances (PFAS), including perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS), in basewide groundwater at the Former Charleston Naval Complex (CNC) located in Charleston, South Carolina are present at concentrations of potential environmental concern. This SAP was prepared under Contract Task Order 112G08005-SE0351, under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N6247016D9008.

The Former CNC was closed in 1996, and since that time, all property has been transferred from the Navy to other U.S. Government entities including the Army Corps of Engineers, Department of State, and Department of Homeland Security and to the CNC Regional Development Authority (RDA). The CNC RDA has subsequently transferred or leased property to other state, local and private entities. Currently, at least 34 private concerns and federal, state, and local government entities own property on the Former CNC, and there are multiple lessees. Approximately 417 acres at the base were transferred to CNC RDA as an "Early Transfer," which allowed economic redevelopment to occur at the same time as environmental cleanup. The Department of Defense Base Realignment and Closure Program Management Office East is responsible for completing all remaining Resource Conservation and Recovery Act corrective action activities necessary to address pretransfer releases of hazardous wastes and/or hazardous constituents on or from the Former CNC.

Tetra Tech has reviewed historical documents at Former CNC and identified numerous areas where PFAS-containing material may have been used or released to the environment on site, including fire-training areas, fire stations, and areas of historical fires. In addition, landfills, sludge pits, maintenance and repair facilities, and other areas within the Former CNC that potentially contain PFAS were identified, along with downgradient areas. Based on this review, many potential sources were identified and then summarized and ranked for prioritization. Upon review of groundwater flow directions relative to the potential highest priority PFAS sources, 19 locations were selected for PFAS sampling. The 19 locations consist of 18 existing monitoring wells and one new drive point location in an area with no existing monitoring wells.

The objective of this initial investigation is to determine whether PFAS are present at concentrations that pose a potential environmental concern in basewide shallow groundwater. This limited investigation is a screening-like investigation and does not include delineation of any contamination encountered. Consultation with the Project Team will be needed to determine the path forward for each sampled source area, with consideration of the possibility that current owner operations may be partly responsible for PFAS contamination as opposed to Navy historical operations. Additional investigation may be necessary for a given source area upon evaluation of analytical results.

This SAP was generated for, and complies with, applicable Uniform Federal Policy for Quality Assurance Project Plans, South Carolina Department of Health and Environmental Control, and United States Environmental Protection Agency Region 4 requirements, regulations, guidance, and technical standards, as appropriate. This SAP outlines the organization, project management, objectives, planned activities, measurement, data acquisition, assessment, oversight, and data review procedures associated with the groundwater sampling activities at Former CNC. Protocols for sample collection, handling and storage, chain of custody, laboratory and field analyses, data validation, and reporting are also addressed herein.

Field activities conducted under this SAP will meet the requirements of the Former CNC Field PFAS Sampling Health and Safety Plan being prepared by Tetra Tech.

CONTENTS

SAP Worksheet #1: Title and Approval Page	1
SAP Worksheet #2: Sampling and Analysis Plan Identifying Information	8
SAP Worksheet #3: Distribution List	11
SAP Worksheet #4: Project Personnel Sign-Off Sheet	
SAP Worksheet #5: Project Organizational Chart	16
SAP Worksheet #6: Communication Pathways	17
SAP Worksheet #7: Personnel Responsibilities Table	20
SAP Worksheet #8: Special Personnel Training Requirements Table	22
SAP Worksheet #9: Project Scoping Session Participants Sheet	23
SAP Worksheet #10: Conceptual Site Model	25
SAP Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements	30
SAP Worksheet #12: Field Quality Control Samples	33
SAP Worksheet #13: Secondary Data Criteria and Limitations Table	34
SAP Worksheet #14: Summary of Project Tasks	35
SAP Worksheet #15: Reference Limits and Evaluation Tables	41
SAP Worksheet #16: Project Schedule/Timeline Table	42
SAP Worksheet #17: Sampling Design and Rationale	43
SAP Worksheet #18: Location-Specific Sampling Methods/SOP Requirements Table	44
SAP Worksheet #19: Field Sampling Requirements Table	52
SAP Worksheet #20: Field Quality Control Sample Summary Table	53
SAP Worksheet #21: Project Sampling SOP References Table	54
SAP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table	57
SAP Worksheet #23: Analytical SOP References Table	58
SAP Worksheet #24: Analytical Instrument Calibration Table	59
SAP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection <code>7</code>	fable65
SAP Worksheet #26: Sample Handling System	66
SAP Worksheet #27: Sample Custody Requirements	67
SAP Worksheet #28: Laboratory QC Samples Table	70
SAP Worksheet #29: Project Documents and Records Table	77
SAP Worksheet #30: Analytical Services Table	78
SAP Worksheet #31: Planned Project Assessments Table	79
SAP Worksheet #32: Assessment Findings and Corrective Action Responses	80
SAP Worksheet #33: QA Management Reports Table	81
SAP Worksheets #34-36: Data Verification and Validation (Steps I and IIa/IIb) Process Table	82
SAP Worksheet #37: Usability Assessment	84
REFERENCES	87

APPENDICES

Revision No: 1

Date: January 18, 2019

- A Field Standard Operating Procedures
- B Field Forms
- C Laboratory Accreditation Documentation
- D Laboratory SOPs
- E Former CNC Well Searches Map and Information

LIST OF FIGURES

NUMBER

- 10-1 PFAS Sampling Locations
- 10-2 Conceptual Site Model for Former Fire Training Areas, Disposal, and Emergency Response
- 10-3 Conceptual Site Model for Fire Stations and Support Operations
- 10-4 Conceptual Site Model for Fire Suppression Systems and Routine Maintenance and Repair Operations

LIST OF TABLES

NUMBER

- 10-1 Site/Facility Ranking and Monitoring Well Locations for PFAS Sampling
- 14-1 PFAS Sampling Requirements

041817/P Page 4 of 89 SE0351

ACRONYMS AND ABBREVIATIONS

Revision No: 1

Date: January 18, 2019

%R Percent recovery

AFFF Aqueous film forming foam

amu Atomic mass unit
AOC Area of Concern

APP Accident Prevention Plan
AST Aboveground storage tank
BCT BRAC Cleanup Team

BEC BRAC Environmental Coordinator
BEQ Bachelor Enlisted Quarters

bgs below ground surface
BRAC Base Realignment and Closure

°C Degree Celsius CA Corrective Action

CCV Continuing calibration verification

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act

CIH Certified Industrial Hygienist

CLEAN Comprehensive Long-Term Environmental Action Navy

CNC Charleston Naval Complex

COR Contracting Officer Representative

CSM Conceptual site model
CTO Contract Task Order
DL Detection Limit

DHEC South Carolina Department of Health and Environmental Control

DO Dissolved oxygen
DoD Department of Defense
DON Department of Navy
DQI Data Quality Indicator
DQO Data Quality Objective

DV Data validation

DVM Data Validation Manager
EB Equipment rinsate blank
EDD Electronic data deliverable

EDR Environmental Data Resources Inc.

ELAP Environmental Laboratory Accreditation Program

°F Degree Fahrenheit
FOL Field Operations Leader
FRB Field reagent blank
FRC Federal Records Center

FTMR Field Task Modification Request

FTS Fluorotelomer Sulfonate

HA Health Advisory

HDPE High-density polyethylene HSM Health and Safety Manager

ICAL Initial calibration

ICV Initial calibration verification

IDQTF Intergovernmental Data Quality Task Force

IDW Investigation-derived waste

IRIS Integrated Risk Information System

ISC Instrument sensitivity check

LCMSMS Liquid Chromatography/ Tandem Mass Spectrometry

LCS Laboratory Control Sample

LCSD Laboratory Control Sample Duplicate

041817/P Page 5 of 89 SE0351

Revision No: 1 Charleston, South Carolina Date: January 18, 2019

LOD Limit of Detection LOQ Limit of Quantification LUC Land use control MB Method blank MD Matrix duplicate mg/L Milligram per liter

mL Milliliter

Measurement Performance Criterion **MPC** Matrix Spike/Matrix Spike Duplicate MS/MSD

miles per hour mph Matrix Spike MS

Matrix Spike Duplicate **MSD**

Mean sea level msl Not applicable NA

NAVFAC Naval Facilities Engineering Command **NEDD** NIRIS electronic data deliverable

N-ethyl perfluorooctanesulfonamidoacetic Acid **NEtFOSAA**

New Hampshire Department of Environmental Services **NHDES**

Nanogram per liter ng/L

NIRIS Naval Installation Restoration Information System **NMeFOSAA** N-methyl perfluorooctanesulfonamidoacetic Acid

NTU nephelometric turbidity unit oxidation-reduction potential ORP

Oil water separator **OWS** Project Action Level PAL Polychlorinated biphenyl PCB

Per- and polyfluoroalkyl substances **PFAS**

PFBS Perfluorobutanesulfonic Acid PFDA Perfluorodecanoic Acid Perfluorododecanoic Acid PFDoA Perfluoroheptanoic Acid PFHpA PFHxA Perfluorohexanoic Acid **PFHxS** Perfluorohexanesulfonic Acid Perfluorononanoic Acid PFNA PFOA Perfluorooctanoic Acid **PFOS** Perfluorooctanesulfonic Acid PFTA Perfluorotetradecanoic Acid PFTrDA Perfluorotridecanoic Acid PFUnA Perfluoroundecanoic Acid

PM **Project Manager**

Program Management Office PMO

Point of Contact POC

POL Petroleum, oil, and lubricants **PQLG** practical quantitation limit goal

Quality assurance QΑ

Quality Assurance Manager MAQ **Quality Assurance Officer** QAO Quality Assurance Project Plan QAPP

QC Quality control

QSM **Quality Systems Manual**

RCRA Resource Conservation and Recovery Act

RDA Regional Development Authority

Reference dose RfD

Remedial Project Manager RPM Relative Percent Difference **RPD**

041817/P Page 6 of 89 SE0351 RSD Relative Standard Deviation
RSL Regional Screening Level
SAP Sampling and Analysis Plan
SDG Sample Delivery Group
Shealy Environmental Services, Inc
SOP Standard Operating Procedure

SPE Solid Phase Extraction
SQL Structured Query Language
SSHO Site Safety and Health Officer
SSHP Site Safety and Health Plan
SWMU Solid Waste Management Unit

TBD To be determined

UFP-QAPP Uniform Federal Policy for Quality Assurance Project Plan

Revision No: 1

Date: January 18, 2019

μg/L Microgram per liter

USEPA United States Environmental Protection Agency

UST Underground storage tank WWTP Wastewater Treatment Plant

SAP Worksheet #2: Sampling and Analysis Plan Identifying Information

Revision No: 1

Date: January 18, 2019

(UFP-QAPP Manual Section 2.2.4)

Site Name/Number: Former Charleston Naval Complex (CNC)

Operable Unit: Not applicable (NA)

Contractor Name: Tetra Tech
Contract Number: N6247016D9008

Contract Title: Comprehensive Long-Term Environmental Action Navy (CLEAN)

Work Assignment

Number (optional): Contract Task Order (CTO) N6945017F0351

- This Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) (USEPA, 2005) and United States Environmental Protection Agency (USEPA) Guidance for Quality Assurance Project Plans, EPA QA/G-5 (2002).
- 2. Identify regulatory program: Resource Conservation and Recovery Act (RCRA).
- 3. This SAP is a project-specific SAP.

4. List organizational partners (stakeholders) and identify the connection with lead organization:

Organization Partners/Stakeholders	Connection
South Carolina Department of Health and Environmental Control (DHEC)	Regulatory Stakeholder

- 5. Lead organization: NAVFAC BRAC PMO East
- 6. If any required SAP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below: None

041817/P Page 8 of 89 SE0351

	ement and Objectives						
Da avvena entatione							
Documentation							
1	Title and Approval Page	NA, Worksheet included					
2	SAP Identifying Information	NA, Worksheet included					
3	Distribution List	NA, Worksheet included					
4	Project Personnel Sign-Off Sheet	NA, Worksheet included					
Project Organization	on						
5	Project Organizational Chart	NA, Worksheet included					
6	Communication Pathways	NA, Worksheet included					
7	Personnel Responsibilities Table	NA, Worksheet included					
8	Special Personnel Training Requirements Table	NA, Worksheet included					
Project Planning/Pi	Project Planning/Problem Definition						
9	Project Scoping Session Participants Sheet	NA, Worksheet included					
10	Conceptual Site Model	NA, Worksheet included					
11	Project Quality Objectives/Systematic Planning Process Statements	NA, Worksheet included					
12	Field Quality Control Samples	NA, Worksheet included					
13	Secondary Data Criteria and Limitations Table	NA, Worksheet included					
14	Summary of Project Tasks	NA, Worksheet included					
15	Reference Limits and Evaluation Tables	NA, Worksheet included					
16	Project Schedule/Timeline Table	NA, Worksheet included					
B. Measurement/E	Data Acquisition						
Sampling Tasks							
17	Sampling Design and Rationale	NA, Worksheet included					
18	Location-Specific Sampling Methods/SOP Requirements Table	NA, Worksheet included					
19	Field Sampling Requirements Table	NA, Worksheet included					
20	Field QC Sample Summary Table	NA, Worksheet included					
21	Project Sampling SOP References Table	NA, Worksheet included					

Date: January 18, 2019

UFP SAP Worksheet #	Required Information	Crosswalk to Related Information		
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table NA, Worksheet included			
Analytical Tasks				
23	Analytical SOP References Table	NA, Worksheet included		
24	Analytical Instrument Calibration Table	NA, Worksheet included		
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	NA, Worksheet included		
Sample Collection	n			
26	Sample Handling System	NA, Worksheet included		
27	Sample Custody Requirements	NA, Worksheet included		
Quality Control S	amples			
28	Laboratory QC Samples Table	NA, Worksheet included		
Data Manageme	nt Tasks			
29	Project Documents and Records Table	NA, Worksheet included		
30	Analytical Services Table	NA, Worksheet included		
C. Assessment	Oversight			
31	Planned Project Assessments Table	NA, Worksheet included		
32	Assessment Findings and Corrective Action Responses Table	NA, Worksheet included		
33	QA Management Reports Table	NA, Worksheet included		
D. Data Review				
34-36	Data Verification and Validation (Steps I and Ila/IIb) Process Table	NA, Worksheet included		
37	Usability Assessment	NA, Worksheet included		

Date: January 18, 2019

QA QC SOP Quality assurance. Quality control. Standard operating procedure.

SAP Worksheet #3: Distribution List

(UFP-QAPP Manual Section 2.3.1)

Personnel listed on this worksheet will be responsible for ensuring that support staff in their organization received a copy of this SAP prior to conducting work governed by this SAP.

Revision No: 1

SAP Recipient	Title/Role	Organization	Telephone Number	Email Address
Mark Easterbrook	NAVFAC BRAC Remedial Project Manager (RPM)/Manages Project Activities for the Navy	NAVFAC BRAC	843-963-4974	mark.easterbrook@navy.mil
Paul Burgio	NAVFAC BRAC Environmental Coordinator (BEC)/Provides Navy program and project management support	NAVFAC BRAC PMO East	215-897-4903	paul.burgio@navy.mil
Todd Bober	Contracting Officer Representative (COR)	NAVFAC BRAC PMO East	215-897-4911	todd.bober@navy.mil
Naval Installation Restoration Information Solution (NIRIS) (final version only)	NIRIS/Database	NAVFAC	NA	NA
Meredith Amick	DHEC Project Manager (PM)/Provides Regulator Input	DHEC	843-898-0368	amickms@dhec.sc.gov
Linda Klink	PM/Daily project management	Tetra Tech	412-921-8650	linda.klink@tetratech.com
To Be Determined (TBD)	Field Operations Leader (FOL)/Coordination and Oversight of Daily Field Operations Site Safety and Health Officer (SSHO)/On-Site Coordination and Oversight of Field Health and Safety	Tetra Tech	TBD	TBD
Tom Johnston, PhD (electronic copy only)	QA Manager (QAM)/Implementation and Oversight of Tetra Tech CLEAN Quality Program	Tetra Tech	412-921-8615	tom.johnston@tetratech.com

SAP Recipient	Title/Role	Organization	Telephone Number	Email Address
Joe Samchuck (electronic copy only)	Data Validation (DV) Manager (DVM)/Manages Data Validation	Tetra Tech	412-921-8510	joseph.samchuck@tetratech.com
Kelly Carper (electronic copy only)	Project Chemist/Provides Coordination with Laboratory	Tetra Tech	412-921-7273	kelly.carper@tetratech.com
Steve Ruffing, PE (copy of cover letter only)	Program Manager/Manages Navy Initiatives	Tetra Tech	757-466-4906	steve.ruffing@tetratech.com
John Trepanowski, PE (copy of cover letter only)	Deputy Program Manager/ Manages Program Activities	Tetra Tech	610-382-1532	john.trepanowski@tetratech.com
Stan Liang, Certified Industrial Hygienist (CIH) [Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) only] (electronic copy)	Health and Safety Manager (HSM)/Manages Corporate Health and Safety Program	Tetra Tech	412-921-4037	stan.liang@tetratech.com
Nisreen Saikaly	Laboratory PM/Directs Laboratory Operations for this Project	Shealy Environmental Services, Inc. (Shealy)	803-227-2704	nsaikaly@shealylab.com

SAP Worksheet #4: Project Personnel Sign-Off Sheet

(UFP-QAPP Manual Section 2.3.2)

Certification that project personnel have read the text will be obtained by one of the following methods, as applicable:

1. In the case of regulatory agency personnel with oversight authority, approval letters or emails will constitute verification that applicable sections of the SAP have been reviewed. Copies of regulatory agency approval letters/emails will be retained in the project files and are listed in Worksheet #29 as project records.

Revision No: 1

Revision Date: January 18, 2019

2. E-mails will be sent to the Navy, Tetra Tech, and subcontractor project personnel who will be requested to verify by email that they have read the applicable SAP/sections and the date on which they were reviewed. Copies of the verification emails will be included in the project files and are identified in Worksheet #29.

Copies of signed Worksheet #s 1 and 4 will be retained in the project files and are identified as project documents in Worksheet #29.

Key personnel will be instructed to read the SAP portions indicated in this worksheet prior to attending an internal site-specific kick-off meeting for field activities. The Tetra Tech PM will track when the reviews have been completed, obtain signatures, and ensure that the completed sign-off sheet is included in the central project file.

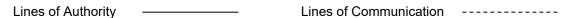
Name	Organization/Title/Role	Telephone Number	Signature/Email Receipt	SAP Section Reviewed	Date SAP Read			
	Navy and Regulator Project Team Personnel							
Mark Easterbrook	NAVFAC BRAC/ RPM/Manages project for the Navy	843-963-4974	Signature on Worksheet #1	All				
Paul Burgio	NAVFAC BRAC PMO East/BEC/ Provides Navy program and project management support	215-897-4903	Either ⁽¹⁾	All				

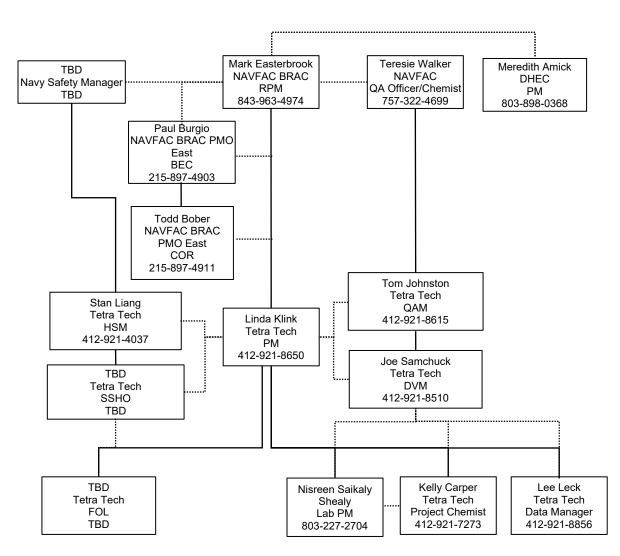
Name	Organization/Title/Role	Telephone Number	Signature/Email Receipt	SAP Section Reviewed	Date SAP Read
Teresie Walker	NAVFAC/QA Officer (QAO)/QA oversight	757-322-4699	See Worksheet #1 for signature	All	
Meredith Amick	DHEC/PM/Provides Regulator Input	843-898-0368	Signature on Worksheet #1	All	
		Tetra Tech Proje	ect Team Personnel		
Linda Klink	Tetra Tech/PM/Manages Daily Operations	412-921-8650	Signature on Worksheet #1	All	
Tom Johnston, PhD	Tetra Tech/QAM/ Manages QA Program and its Implementation	412-921-8615	Signature on Worksheet #1	All	
TBD	Tetra Tech FOL/SSHO/ Oversees operational and health and safety aspects in the field	TBD	Either ⁽¹⁾	All	
Joe Samchuck (electronic copy only)	Tetra Tech/DVM/ Oversees Data Validation	412-921-8510	Either ⁽¹⁾	Worksheet #s12, 14, 15, 19, 20, 23- 28, 30, and 34-37	
Kelly Carper (electronic copy only)	Tetra Tech Project Chemist/Provides Coordination with Laboratory	412-921-7273	Either ⁽¹⁾	Worksheet #s 6, 12, 14, 15, 19, 23- 28, 30, and 34-36	
Stan Liang	Tetra Tech/HSM/ Manages Corporate Health and Safety Program	412-921-4037	See APP/SSHP for signature	APP/SSHP	

Name	Organization/Title/Role	Telephone Number	Signature/Email Receipt	SAP Section Reviewed	Date SAP Read		
	Subcontractor Personnel						
Nisreen Saikaly	Shealy/Laboratory PM/Manages Daily Operations	803-227-2704	Either ⁽¹⁾	Worksheet #s 6, 12, 14, 15, 19, 23- 28, 30, and 34-36			

¹ In lieu of gathering signatures on this worksheet, the Tetra Tech PM may obtain email acknowledgements that individuals have read and will execute the appropriate portions of the SAP as indicated above.

SAP Worksheet #5: Project Organizational Chart





Revision No: 1

SAP Worksheet #6: Communication Pathways

(UFP-QAPP Manual Section 2.4.2)

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)	
Draft SAP Review/Revisions	Tetra Tech PM NAVFAC QAO/Chemist	Linda Klink Teresie Walker	412-921-8650 757-322-4699	Within 2 days of completing the draft SAP, the SAP will be submitted to NIRIS by the Tetra Tech PM. NAVFAC QAO/Chemist comments will be resolved to the satisfaction of the QAO/Chemist, and the SAP will be uploaded to NIRIS for QAO/Chemist signature.	
SAP Changes Prior to Field/ Laboratory Work	Tetra Tech FOL Tetra Tech PM NAVFAC BEC NAVFAC BRAC RPM	TBD Linda Klink Paul Burgio Mark Easterbrook	TBD 412-921-8650 215-897-4903 843-963-4974	The Tetra Tech PM will document the required change via a Field Task Modification Request (FTMR) form within 5 days and send it to the NAVFAC RPM and BEC. If necessary, the PM will submit a concurrence letter within 7 days of identifying the need for change. SAP amendments will be submitted by the Tetra Tech PM to the Navy RPM and BEC for review and approval. At the BEC/RPM's discretion, SAP changes will be to the NAVFAC QAO for approval (e.g., when significant DQO-related changes occur, or the laboratory is changed). The Tetra Tech PM will communicate scope changes to the Project Team via e-mail within 1 business day.	
Regulatory Agency Interface	NAVFAC RPM	Mark Easterbrook	843-963-4974	When due according to the project schedule, the SAP will be submitted to the regulatory agency by NAVFAC RPM or designee. NAVFAC RPM will intedirectly, via phone or email as needed.	
Field Progress Reports	Tetra Tech FOL	TBD	TBD	The Tetra Tech FOL will provide email or verbal reports to the Tetra Tech PM on a schedule arranged by the PM.	
Stop Work Due to Safety Issues	Tetra Tech FOL Tetra Tech PM NAVFAC BEC NAVFAC BRAC RPM	TBD Linda Klink Paul Burgio Mark Easterbrook	TBD 412-921-8650 215-897-4903 843-963-4974	If Tetra Tech is the responsible party for a stop work command, the Tetra Tech FOL will inform on-site personnel, subcontractor(s), the Navy BEC and RPM, and identified Project Team members within 1 hour (verbally or by e-mail).	

Revision No: 1

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)	
		TBD Linda Klink		The Tetra Tech FOL will verbally inform the Tetra Te PM within 24 hours of realizing the need for a change.	
SAP Changes in the Field	Tetra Tech FOL Tetra Tech PM		TBD 412-921-8650	The Tetra Tech PM will document the change via an FTMR form within 5 days and send it to the Navy BEC and RPM. If necessary, a concurrence letter will be submitted within 7 days of identifying the need for a change. The NAVFAC RPM will establish the required level of review.	
Reporting Laboratory Quality Variances	Laboratory PM Tetra Tech Project Chemist Tetra Tech PM	Nisreen Saikaly Kelly Carper Linda Klink	803-227-2704 412-921-7273 412-921-8650	The Laboratory PM will notify (verbally or via e-mail) the Tetra Tech Project Chemist within 1 business day of when an issue related to laboratory data is discovered. The Tetra Tech Project Chemist will notify (verbally or via e-mail) the data validation staff and Tetra Tech PM within 1 business day. Corrective actions (CAs) may include a consult with the RPM and, at the RPM's discretion, with the NAVFAC QAO/Chemist. The Laboratory QAM will document all quality variances in the Case Narrative of the Analytical Laboratory Report.	
Field CAs	Tetra Tech FOL Tetra Tech PM	TBD Linda Klink	TBD 412-921-8650	The Tetra Tech FOL will initiate CAs and will notify the Tetra Tech PM verbally within 1 business day of taking action.	
Sample Receipt Variances	Laboratory PM Tetra Tech FOL Tetra Tech PM Tetra Tech Project Chemist	Nisreen Saikaly TBD Linda Klink Kelly Carper	803-227-2704 TBD 412-921-8650 412-921-7273	The laboratory sample custodian will report variances to the Tetra Tech FOL, Tetra Tech Chemist, or PM verbally or via email within 24 hours of identifying a variance and those individuals will attempt to resolve the variance with the laboratory. If the variance cannot be resolved, the Tetra Tech PM will notify the NAVFAC RPM verbally or via email within 1 business day of the variance being brought to her attention. If necessary, the NAVFAC RPM will take CA commensurate with the deficiency.	
Analytical Corrective Actions	Laboratory PM Tetra Tech FOL Project Chemist Tetra Tech PM NAVFAC RPM	Nisreen Saikaly TBD Kelly Carper Linda Klink Mark Easterbrook	803-227-2704 TBD 412-921-7273 412-921-8650 843-963-4974	If the impact of an identified deficiency is limited to this project, it will be resolved between the laboratory PM and Tetra Tech PM and support staff and will be documented in the project report. If the deficiency is systemic and potentially affects other projects, the Tetra Tech PM will verbally advise the NAVFAC RPM within 24 hours of notification from the Project Chemist or DVM. The NAVFAC RPM will take CA appropriate for the identified deficiency. CAs may include a consult with the NAVFAC QAO/Chemist and coordination with the laboratory.	

Revision Date: January 18, 2019

be resolved to the satisfaction of the NAVFAC RPM, revisions will be made, and the report will be finalized for

final distribution and submittal to NIRIS.

Notes: The FOL for this project will also serve as the SSHO.

SAP Worksheet #7: Personnel Responsibilities Table

(UFP-QAPP Manual Section 2.4.3)

Name	Title/Role	Organizational Affiliation	Responsibilities
Mark Easterbrook	NAVFAC RPM/ Manages project for the Navy	NAVFAC BRAC	Oversees overall project performance, financial statements, scheduling, and implementation, including scoping, data review, and evaluation, and approves the SAP.
Paul Burgio	NAVFAC BEC/ Provides Navy program and project management support	NAVFAC PMO East	Provides Navy program and project management support.
Todd Bober	NAVFAC COR/ provides project Navy contracting support	NAVFAC PMO EAST	Provides project Navy contracting support.
Meredith Amick	PM/ Provides regulator input	DHEC	Participates in scoping, data review, and evaluation and approves the SAP. Oversees project execution for DHEC.
Linda Klink	PM/ Manages daily operations	Tetra Tech	Ensures that health and safety requirements are implemented. Oversees project, financial, schedule, and technical day to day management of the project. Oversees project implementation, including scoping, data review, and evaluation for this project. Coordinates and oversees preparation and review of Tetra Tech project deliverables.
Tom Johnston	QAM/ Directs the Tetra Tech CLEAN QA Program	Tetra Tech	Ensures that quality aspects of the Tetra Tech CLEAN QA program are implemented. Oversees review of the SAP, approves the SAP, oversees preparation of laboratory scopes of work, coordinates with the laboratory, and conducts data quality reviews.
Stan Liang	CLEAN Health and Safety Manager/ Directs the Health and Safety Program	Tetra Tech	Ensures that health and safety aspects of the Tetra Tech CLEAN Health and Safety Program are implemented. Oversees review of health and safety documents, and approves health and safety documents.
TBD	FOL/SSHO/ Directs and provides oversight of routine field activities and monitors health and safety aspects of field work	Tetra Tech	Supervises, coordinates, and performs field sampling activities. Ensures that health and safety requirements are implemented during field work. Functions as the on-site communications link between field staff members, the Facility POC, and the Tetra Tech PM. Oversees mobilization and demobilization of all field equipment and subcontractors. Ensures proper maintenance of site logbooks, field logbooks, and field recordkeeping. Identifies and resolves problems in the field, resolving difficulties via consultation with the NAVFAC BRAC BEC and RPM, implementing and documenting CA procedures, and facilitating communication between the field team and project management. Responsible for on-site project-specific health and safety training and monitoring site conditions. Details of health and safety responsibilities are presented in the APP/SSHP.

Revision No: 1

Name	Title/Role	Organizational Affiliation	Responsibilities
Kelly Carper	Project Chemist/ Serves as focal point for chemistry-related issues	Tetra Tech	Coordinates analyses with laboratory chemists, ensures that the laboratory scope of work is followed and that QA has been performed for QA data packages, and communicates with Tetra Tech staff. Ensures that the project meets objectives from the standpoint of laboratory performance. Provides technical advice to the Tetra Tech team on project chemistry matters. Functions as the primary interface between the subcontracted laboratory and Tetra Tech PM. Ensures completion of Tetra Tech DV.
Joe Samchuck	DVM/Directs and provides oversight of routine field activities		Manages DV activities within Tetra Tech, including ensuring QA of DV deliverables, providing technical advice on data usability, and coordinating and maintaining the DV review schedule.
Lee Leck	Data Manager/Manages data receipt, database uploads, and data archiving	Tetra Tech	Coordinates data receipt and upload to Tetra Tech and Navy databases; and manages and controls the flow of data to ensure that data are secure.
Nisreen Saikaly	Laboratory Project Manager/Directs and provides oversight of laboratory activities		Coordinates analyses with laboratory chemists, ensures that the laboratory scope of work is followed, performs QA of data packages, and communicates with Tetra Tech staff.

SAP Worksheet #8: Special Personnel Training Requirements Table

(UFP-QAPP Manual Section 2.4.4)

Project-specific safety requirements are addressed in greater detail in the project-specific APP/SSHP.

Revision No: 1

SAP Worksheet #9: Project Scoping Session Participants Sheet

(UFP-QAPP Manual Section 2.5.1)

Project Name: Basewic Investigation	le PFAS Groundwater Screening	Site	Site Name: Former CNC				
Projected Date(s) of Sampling:	Approximately July/August 20)18 Site	Site Location: Charleston, South Carolina				
Project Manager: Mark	Project Manager: Mark Easterbrook						
Date of Session: April	Date of Session: April 10, 2018 BRAC Cleanup Team (BCT) Meeting						
Scoping Session Purpose: Discuss plans and scope for PFAS sampling							
Name *	Title	Affiliation	Phone Number	E-mail Address	Project Role		
Mark Easterbrook	RPM	Navy BRAC	843-963- 4974	mark.easterbrook@navy.mil	RPM		
Paul Burgio	NAVFAC BEC	Navy BRAC PMO East	215-897- 4903	paul.burgio@navy.mil	Navy oversight		
Meredith Amick	Environmental Engineer	DHEC	803-898- 0368	amickms@dhec.sc.gov	PM		

Revision No: 1

Revision Date: January 18, 2019

Comments/Decisions:

The team discussed and acknowledged that the work scope is similar to a Preliminary Assessment/Site Inspection (PA/SI) to generally determine the "presence or absence" of PFAS at the Former CNC base wide and not to determine the extent of contamination. The scope includes sampling of groundwater from 20 monitoring wells for PFAS analysis, using existing wells, if at all possible. The Navy summarized the associated work completed to date by Tetra Tech, including research of potential PFAS sources, ranking of PFAS sources, and coordination of the PFAS mapping effort with the land use control (LUC) management mapping task to allow overlay of property owners and zones to aid in pending field logistics. The research effort considered LUCs, existing and demolished building usages over time, Areas of Concern (AOCs)/Solid Waste Management Units (SWMUs) designations (including those with No Further Action decisions, considering that PFAS sampling was not previously conducted), and maps from the Tetra Tech 2017 site visit including a visit to the map room which focused on the fuel system where the foam suppression system was indicated.

The team acknowledged the problems associated with determining the status of monitoring wells at the Former CNC, considering the large number of historical wells and lack of complete documentation on those that have been abandoned over the years.

^{*} Names limited to those at the BCT meeting involved with PFAS decision making. As directed by the Navy, no formal scoping session was conducted for this PFAS groundwater investigation because the Navy scope is for a first-step PFAS investigation at the facility to evaluate the "presence or absence."

Action Items:

- Near term:
 - The team acknowledged the problems associated with determining the status of monitoring wells at Former CNC (as discussed above), and the Navy will work with CH2M Hill, the contractor responsible for facility-wide performance based remediation, and Tetra Tech to identify and confirm the active status of the proposed wells for PFAS sampling.

Revision No: 1

Revision Date: January 18, 2019

- Schedule: Tetra Tech will integrate the PFAS mapping and summary table into the SAP. Tetra Tech will provide the SAP for Navy and Navy Chemist review in April 2018. Anticipated submittal for regulatory review will be in late May/early June. SAP finalization is anticipated for mid-July, with field work in late July/early August. ***The Navy needs PFAS analytical results by the end of Fiscal Year 2018 (September), so it is important to prioritize SAP reviews. ***
- <u>Future</u>: Determine the path forward, including the need for additional investigation and new monitoring well installation based on PFAS results. ***Upon source identification, determine if any PFAS detected is attributed to past Navy operations as opposed to the operations of current occupants. ***

Consensus Decisions: None.

SAP Worksheet #10: Conceptual Site Model

(UFP-QAPP Manual Section 2.5.2)

This worksheet describes the overall conceptual site model (CSM) for the Former CNC relative to sites where potential PFAS-containing material may have been used or released to the environment. Tetra Tech has reviewed historical documents at Former CNC and identified numerous areas where PFAS-containing material may have been used or released on site, including fire training areas, fire stations, and areas of historical fires. In addition, landfills, sludge pits, maintenance and repair facilities, and other areas within the Former CNC that potentially contain PFAS were identified, along with downgradient areas. Based on this review, many potential PFAS sources were identified, summarized, and ranked according to the relative likelihood of release based on Tetra Tech's research of site operations and understanding of typical PFAS potential sources. Upon review of groundwater flow directions relative to the rankings, 19 locations were selected for PFAS sampling. The 19 locations consist of 18 existing monitoring wells and one new drive point location in an area with no existing monitoring wells. Identification and prioritization information, document references, and groundwater flow directions associated with potential PFAS sources are summarized in Table 10-1. Table 10-1 also identifies the 19 locations selected for sampling and rationales for their selection, which were based on this CSM and are described in greater detail in Worksheet #18. Because of the large size of the base, and the level of detail required for investigations, the CNC has been divided into investigative zones, identified as A through L, as shown on Figure 10-1. The potential sources also are shown Figure 10-1, along with the 19 selected locations for sampling.

Revision No: 2

Date: March 21, 2019

The following presents a short summary of the facility-specific CSM with regard to potential historical PFAS use, release, and/or storage.

10.1 Former CNC Description

The Former CNC is in the City of North Charleston, on the western bank of the Cooper River in Charleston County, South Carolina (see Figure 10-1). This installation consists of two major areas: (1) an undeveloped dredged materials area on the eastern bank of the Cooper River on Daniel Island in Berkeley County and (2) a developed area on the western bank of the Cooper River in Berkeley County. In addition, a CNC Annex is present several miles from the main base area, near Charleston Air Force Base (not shown Figure 10-1). The land use surrounding the CNC is mature urban, having long been developed with commercial, industrial, and residential properties. Commercial areas are primarily west of the CNC; industrial areas lie primarily north of the CNC and along the western bank of Shipyard Creek.

Additional details concerning the CSM, including historical site activities, past investigations, and current site conditions are provided below.

10.2 Potential Sources of PFAS

PFAS are a class of anthropogenic compounds characterized by carbon chains of varying lengths containing carbon-fluorine bonds. The strong electronegative force of the carbon-fluorine bond requires a large amount of energy to break, which makes PFAS extremely resistant to biodegradation, photo-oxidation, direct photolysis, and hydrolysis. In addition to their environmental persistence, PFAS are readily miscible in aqueous solutions and therefore have a high affinity for aqueous transport via migration to groundwater from soil and with subsequent downgradient groundwater flow. These qualities of persistence and mobility flag PFAS for potential concern if released into the environment. PFAS are generally unlikely to volatilize and do not readily sorb to soil.

General Uses of PFAS

From a commercial standpoint, the chemical properties of PFAS make them useful surfactants and surfaceactive agents able to repel oil, grease, and water. For these reasons, PFAS have been manufactured for use in a wide variety of products including fire-fighting foams (particularly aqueous film-forming foam [AFFF]), non-stick cookware, fiber and fabric stain protection products, food packaging, and personal care products. The pervasive use of PFAS in commercial and industrial products has led to the discovery of PFAS in soil, air, and groundwater at storage and production facilities and at private and government-owned facilities.

Revision No: 1

Date: January 18, 2019

Key PFAS Sources at Naval Installations

PFAS have been used in a variety of military applications, including as a component in AFFF, which was routinely used at fire-fighting training areas and equipment test areas, and is still used at crash sites and in some fire-suppression systems in hangars. The current military specification for AFFF has a maximum limit for PFOS and PFOA of 800 parts per billion (NAVSEA, 2017). In addition, current and historical AFFF storage and transfer areas are of potential concern for releases of PFAS to the environment. Historical reports of uncontrolled spills and the repeated use of AFFF during fire training and firefighting have been correlated with higher concentrations of PFASs in biota, surface water, and groundwater (Place and Field, 2012). Therefore, a key element for identifying significant PFAS sources at Department of Navy (DON) facilities is the storage and use of AFFF.

PFAS from AFFF used in firefighting and fire suppression-systems are considered to have the greatest potential for release to the environment in terms of mass and concentration at DON installations. Other potential sources of PFAS to the environment include historical on-site land disposal areas/landfills containing operations wastes (e.g., from electroplating), waste-water treatment sludges and effluents, and PFAS materials themselves. Landfill leachate could carry PFAS to groundwater.

The following sections provide further discussion of these potentially significant DON sources of PFAS.

AFFF in Firefighting Exercises and Fire Suppression

AFFFs are water based (60 to 90 percent) and frequently contain hydrocarbon-based surfactants such as sodium alkyl sulfate and fluorosurfactants, such as fluorotelomers, perfluorocatanoic acid (PFOA), and perfluorocatanesulfonic acid (PFOS). AFFF-containing PFAS were developed in the early to mid-1960s for use on Class B fires and were generally put into routine use by the early 1970s. PFAS are still required as an integral component of AFFF by military specification. AFFF that was used at the Former CNC may have been released to the environment, potentially impacting surface and subsurface soil, groundwater, sediment, and surface water.

AFFFs have the ability to spread over the surface of hydrocarbon-based liquids (i.e., create a film). This limits oxygen from contacting the surface of the ignited fuel, while simultaneously cooling the surface because of their high water content, and prevents volatile fuels from escaping as ignitable vapor. These qualities make AFFF very effective for extinguishing burning aviation fuels.

Companies including 3M, DuPont, Ansul, and Chemguard were the primary producers that used fluorocsurfactants in the production of AFFF. Typically, AFFF concentrate was proportionally mixed into water lines using in-line eductors or other proportioning devices to create the necessary foam solution ranging from 3% to 6% of the concentrate. As noted, AFFF was primarily used for Class B (flammable liquid or gas) fuel fires because the chemical properties of PFAS in AFFF created a thick foam blanket. Class A (ordinary combustibles) fire-fighting foams were used to extinguish wood and grass fires and do not contain PFAS. Therefore, Class A fire-fighting foams are not sources of PFAS.

Areas of interest for this PFAS investigation include those where AFFF may have been applied or stored. These include current and former fire-training areas, equipment test and cleanout areas, fire-fighting infrastructure (hangars, fire stations, AFFF storage/handling areas, pump houses, etc.), unplanned release areas such as areas with previous emergency responses to spills, equipment cleaning discharge locations, and fire suppression systems located at fuel storage area(s).

Electroplating

In general, electroplating, specifically hard chromium plating, is an industrial activity where PFAS-containing mist suppressants may have been used. Electroplating consists of creating an electrolytic cell that enables a thin layer of metal to be deposited onto an electrically conductive metal surface. PFAS were sometimes

used during the chromium electroplating process as a surfactant in chromic acid baths. As a surfactant, PFAS lowered the surface tension (adhesion of materials) by creating a thin, foamy layer on the surface of the chrome bath for mist suppression. This mist suppressant reduced the formation of airborne chromium aerosols during the plating process, which are known to be carcinogenic and allergenic. Areas where non-chromium electroplating operations were carried out would not be expected to have used PFAS-containing mist suppressants.

Revision No: 1

Date: January 18, 2019

Landfill Operations, Waste Disposal Areas, and Wastewater Treatment Plants

Historically, landfills received wastes generated from military installations, including waste streams from operational areas (machine shops), housing areas, and waste from wastewater treatment plants (WWTPs) and/or homeported ships. These waste streams may contain industrial and/or consumer products that were either manufactured with PFAS or contain PFAS constituents that may leach out of the landfill. Additionally, waste material biosolids and sludge from WWTPs can contain PFAS.

Other Potential Sources

Due to the widespread use of PFAS, there may be Navy activities other than the ones mentioned above where PFAS were used. PFAS have been used in some detergents and have been reported in groundwater near car washes at a New Hampshire site (NHDES, 2017), and PFAS have been included in some stain-resistant paint formulations. It is possible that in significant amounts, these could be sources of PFAS to the environment.

PFAS Potential Sources at Former CNC

PFAS releases are suspected to have occurred via the following primary mechanisms at the Former CNC (including associated CSM figures are references):

- Routine training activities at former firefighter training areas (Figure 10-2).
- AFFF use occurring during responses to emergency operations related to spills (Figure 10-2).
- AFFF-impacted materials disposed of in landfills or pits (Figure 10-2).
- Routine storage and handling of AFFF at fire stations (Figure 10-3).
- Routine storage and laundering of fire fighter suits (Figure 10-3).
- Potential releases from AFFF fire-suppression systems such as those known to have been in use at fuel storage tank farms (Figure 10-4).
- Potential releases from routine maintenance and repair operations that may have resulted in release of PFAS-containing substances associated with lubricants, paints, and/or plating operations (Figure 10-4).

Figures 10-2, 10-3, and 10-4 show the CSM for each of these release mechanisms. Individual sites are discussed in more detail in Table 10-1.

10.3 Environmental Setting

Physiography

The Former CNC is located in the lower South Carolina Coastal Plain Physiographic Province on the Cooper River side of the Charleston Peninsula, which is formed by the confluence of the Cooper and Ashley Rivers. The topography of the Former CNC is essentially flat, with elevations ranging from just over 20 feet above mean sea level (msl) in the northwestern part to sea level at the Cooper River. Much of the original topography of the Former CNC has been modified by human activities.

Geology

The geology of the Charleston, South Carolina, area is typical of the southern part of the Atlantic Coastal Plain. A seaward-thickening wedge of Cretaceous and younger sediments is underlain by older igneous and metamorphic basement rock. At the Former CNC, Recent and/or Pleistocene sands, silts, and clays of high organic content are exposed at the surface. These materials are underlain by a plastic calcareous clay known as the Cooper Marl. The Cooper Marl is underlain by the Santee Limestone and older rocks.

The surface soils on the Former CNC have been extensively disturbed and reworked by a history of intensive use and improvement. The natural surface soils were probably fine-grained materials typical of tidal marsh environments.

Revision No: 1

Date: January 18, 2019

Hydrogeology

In the Charleston area, the Cooper Marl is rather impermeable and acts as the confining bed for the Santee Limestone, which is not as permeable as in other areas and forms a confined aquifer. Groundwater in the Santee, which occurs at about 328 feet below msl, flows generally to the southeast. Some wells in the vicinity of the Former CNC are pumping from the Santee for industrial purposes. In the shallow aquifer on the Former CNC, water flows southeast and east toward the Cooper River or Shipyard Creek. The water table is within 3 to 7 feet of the ground surface, and shallow groundwater continually discharges to the Cooper River and Shipyard Creek. Local variations in groundwater flow, such as radial flow, are possible due to the shallow water table and localized influences of topography.

10.4 Receptors

Land uses at the Former CNC includes industrial, commercial, and recreational. Under these land uses typical receptors representative of all possible exposures are occupational workers, construction workers, trespassers, and recreational users. If land use would change to allow residential use the most sensitive receptors would be the child and adult residents who would repeatedly be exposed to groundwater as drinking water. Although this is not likely, the Navy has designed this study to protect these most sensitive receptors which means that any decision made in accordance with this SAP will also be protective of the other representative receptors. Potentially complete exposure pathways also exist for ecological receptors; however, there are no ecological criteria for therefore the data to will be used to further develop the CSM. All property has been transferred from the Navy to other entities including the Army Corps of Engineers, Department of State, Department of Homeland Security, and Regional Development Authority (RDA). The CNC RDA has subsequently transferred or leased property to other state, local and private entities. Currently, at least 34 private concerns and federal, state, and local government entities own property on the Former CNC, and there are multiple lessees.

The groundwater is not used for drinking water purposes, and LUCs are in place preventing use of groundwater in all areas of the facility. Records (Trevet, 2016) identified no domestic use wells on the Charleston Complex, inclusive of the former Naval Station and former Naval Shipyard. Domestic use wells were identified within three miles of the Charleston Complex, although not downgradient. Wells identified across the Cooper River from the Complex are not likely to be impacted because domestic water supplies in the area of the Complex are from shallow groundwater that do not impact domestic supplies on the far side of the river. Refer to Appendix E for a depiction of former CNC well locations (Trevet, 2016 [Figure 8]), as well as additional information from the Trevet report including a table with supply well information and the supporting Environmental Data Resources Inc (EDR) Report that includes the requested location information.

10.5 PFAS Background

As noted above, PFAS are an environmental concern and considered an emerging contaminant by USEPA and DON. Emerging contaminants can be broadly defined as any naturally occurring or synthetic chemical or microorganism that is not commonly monitored in the environment but that has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects. In many instances, emerging contaminants typically do not have (or have evolving) promulgated cleanup standards and risk-based action levels, making implementation of response actions difficult. USEPA has established lifetime health advisories (HAs) for PFOA and PFOS from drinking water exposure at concentrations of 0.07 micrograms per liter (µg/L) (or 70 nanograms/liter [ng/L]), individually or combined. Some states are considering drinking water standards that are even lower. At this time, the State of South Carolina does not have a drinking water standard for any of the PFAS. Research is ongoing to understand the behavior of PFAS in the environment and their potential toxicity and impacts to human health and the environment.

Health Effects

In May 2016, the USEPA Office of Water issued a lifetime drinking water HA of 70 ng/L for both PFOA and PFOS. These HAs were developed to assist federal, state, and local officials in evaluating risks from these unregulated (emerging) contaminants. The USEPA Office of Water lifetime drinking water HA for PFOA is based on a reference dose (RfD) derived from a developmental toxicity study using mice. The critical effects of the study included reduced ossification in proximal phalanges and accelerated puberty in male pups following exposure during gestation and lactation (USEPA, 2016a). The HA for PFOS is based on an RfD derived from a developmental toxicity study in rats; the critical effect in this study was decreased pup body weight following exposure during gestation and lactation (USEPA, 2016b). PFOA and PFOS are known to be transmitted to the fetus in cord blood and to the newborn in breast milk. Because the developing fetus and newborn are particularly sensitive to PFOA- and PFOS-induced toxicity, the RfDs based on developmental effects are also protective of adverse effects in adults (e.g., liver and kidney toxicity). The lifetime HA is therefore considered protective of the population at large. In May 2016, the USEPA Office of Water issued a lifetime drinking water HA of 70 ng/L for both PFOA and PFOS. These HAs were developed to assist federal, state, and local officials in evaluating risks from these unregulated (emerging) contaminants. They are based on toxicity assessments conducted by the Office of Water, not on toxicity criteria published in the USEPA's Integrated Risk Information System (IRIS). HAs are not legally enforceable drinking water standards.

Revision No: 1

Date: January 18, 2019

Regulatory Background on PFAS

In 2006, USEPA initiated the 2010/2015 PFOA Stewardship Program in which eight major companies committed to reduce facility emissions and product contents of PFOA and related chemicals on a global basis by 95 percent no later than 2010 and to work toward eliminating emissions and product content of these chemicals by 2015. All companies have met the program goals. To meet the goals, most companies stopped the manufacture and import of long-chained PFAS, and then transitioned to alternative chemicals. Other companies exited PFAS industries altogether. On January 21, 2015, USEPA proposed a Significant New Use Rule under the Toxics Substances Control Act to require manufacturers (including importers) of PFOA and PFOA-related chemicals, including as part of articles, and processors of these chemicals to notify USEPA at least 90 days before starting or resuming new uses of these chemicals in any process.

SAP Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements

(UFP-QAPP Manual Section 2.6.1)

The planned data collection at the Former CNC is designed to evaluate the presence of PFAS in site groundwater at concentrations of potential environmental concern. Data Quality Objectives (DQOs) for this investigation were developed based on USEPA's *Guidance for Systematic Planning Using the DQO Process* (2006) and are presented in this section.

Revision No: 1

Date: January 18, 2019

11.1 Problem Statement

PFAS are components of AFFF and other sources that were used and potentially released and/or spilled at multiple locations at the facility. The Project Team needs to determine whether PFAS are present at concentrations of potential environmental concern in shallow basewide groundwater and, if necessary, to recommend additional actions to address presence of PFAS. This limited investigation is a screening-like investigation and does not include delineation of any contamination encountered. Consultation with the Project Team will be needed to determine the path forward for each sampled source area, with consideration of the possibility that current owner operations may be partly responsible for PFAS contamination as opposed to Navy historical operations. Additional investigation may be necessary for a given source area upon evaluation of analytical results. The PFAS compounds to be evaluated during this investigation are identified in Worksheet #15.

11.2 Information Inputs

Data that are required to resolve the problem described in Section 11.1 are as follows:

- Chemical Data: PFAS concentrations in shallow groundwater. The PFAS of interest are listed in Worksheet #15. Groundwater will be collected from existing permanent monitoring wells and one hand-driven drive point location as discussed in Worksheet #17. There are no existing monitoring wells in or downgradient of the area of the proposed drive point groundwater sample.
- **Field Measurements**: Measurements of field parameters (temperature, dissolved oxygen [DO], pH, specific conductance, oxidation-reduction potential [ORP], and turbidity) from the sampling locations to determine when low-flow groundwater purge stabilization is complete.
- **Groundwater Level Measurements:** Historical documentation provides detailed findings of groundwater flow conditions; therefore, no comprehensive groundwater level measurement data are needed. Moreover, the sampling locations are widespread throughout the Former CNC and so it would not be possible to prepare and properly interpret potentiometric surface maps.
- Project Action Limits: At this time, the USEPA HAs (USEPA, 2016a and b) have been identified as screening levels for PFOS and PFOA as discussed in Worksheet #10. USEPA's drinking water HAs for PFOS and PFOA state that when PFOS and PFOA "co-occur at the same time and location in a drinking water source, a conservative and health-protective approach is to compare the sum of the concentrations" (PFOA + PFOS) to the HA of 70 ng/L (USEPA, 2016c). The screening level for perfluorobutanesulfonic acid (PFBS) has been identified as the USEPA tapwater Regional Screening Level (RSL) of 380,000 ng/L (2017a), reflecting a target cancer risk of 1E-06 and target hazard quotient of 1. If screening levels change prior to the field event at Former CNC, Worksheet #15 will be amended via a SAP Amendment to document any changes to screening levels. If screening levels change after the field event begins, Worksheet #15 will be amended via an FTMR.

The selected screening levels are presented and referenced in Worksheet #15.

To conduct comparisons of site data to the screening levels, the selected laboratory must be able to achieve Limits of Quantitation (LOQs) that are low enough to measure PFAS concentrations less than the screening levels. Analytical data reported by the laboratory will use the following reporting conventions: All concentrations less than the Detection Limit (DL) will be considered non-detects and will be reported as the Limit of Detection (LOD) value with a "U" qualifier; and concentrations between the DL and LOQ will be reported as estimated values with a "J" qualifier. If a target analyte has a screening value between the DL and LOQ, the "J" flagged data will be accepted as reported, and the effect of increased relative measurement uncertainty in this concentration range will be considered by the Project Team when comparing results to screening values (see Worksheet #15).

Revision No: 1

Date: January 18, 2019

11.3 Study Boundaries

The groundwater population of interest is the base wide surficial aquifer at various sites located at the Former CNC. The shallow aquifer represents the groundwater most likely to be contaminated with PFAS based on the CSM. The sites and well locations are identified in Table 10-1 and are depicted on Figure 10-1. With the exception of one new hand-driven point location, sampling is constrained to existing shallow wells that exist throughout the Former CNC. The locations selected for sampling are believed to be biased high because they are located near PFAS sources. Also, the locations are spread spatially to encompass much of the Former CNC. As such, results are expected to allow an extrapolation base wide as to whether or not PFAS is present or absent at Former CNC.

11.4 Analytic Approach

The following decision rule quantifies the planned analytical approach for the Former CNC PFAS groundwater investigation.

Decision Rule:

If measured concentrations of PFOS, PFOA, or PFBS in shallow groundwater samples are all less than the project action levels (PALs) established in Worksheet #15, then convene the Project Team to discuss a possible recommendation for no further groundwater sampling; otherwise, develop a plan for delineating the PFAS plume(s) and convene the Project Team to determine the need for additional investigation to evaluate potential risk and modify this SAP for additional work, as needed.

For a given potential PFAS source area within the basewide investigation, the associated existing well(s) for sampling may not be in an optimal location. For example, the well(s) may be significantly downgradient of a given potential PFAS source area and so the report may only be able to determine that a large plume of contamination is not present, when in fact, a smaller plume may be present closer to the source and with concentrations that do exceed the PALs. For a given source area, depending on results, additional site research may be necessary, for example, refinement of groundwater flow direction, and/or research of current owner operations compared to Navy historical operations. Weight of evidence will also be a consideration. For example, if a fire station potential PFAS source area did not have any nearby existing wells, but site history is very similar to another fire station potential site that does have an optimally placed well(s), then the results from the latter may guide the team in deciding the path forward for the former. That is why it is important to convene the team for additional discussion on the path forward, even if screening criteria are not exceeded.

11.5 Performance Criteria

Samples for chemical analyses will be collected from biased locations in areas most likely representative of the Former CNC based on the current CSM. The Project Team will use the results of this investigation to determine whether the quality of data collected is sufficient to support the attainment of project objectives and to decide whether further investigation is required. Performance criteria for laboratory-generated data are analysis-specific laboratory QA limits and DLs for target analytes as listed in Worksheet #15.

The data quality will be reviewed to ensure that performance criteria, as listed in Worksheets #24 and #28, have been met and that the data are sufficient for decision-making purposes. If all data are collected as

planned and no data points are missing or rejected for quality reasons, then the investigation completeness will be considered satisfactory. If any data gaps are identified, including missing or rejected data, the Project Team will assess whether a claim of having obtained project objectives is reasonable based on the quantity and types of data gaps. Project Team members will be involved in rendering the final conclusion by consensus regarding the adequacy of the data.

Revision No: 1

Date: January 18, 2019

To limit uncertainty in field and laboratory data, performance criteria for field collection and laboratory analysis will be measured. Performance criteria are described in Worksheet #s 12, 15, and 28.

11.6 Sampling Design

This biased sampling design was developed to optimize resources and generate data to satisfy the DQOs. In particular, use of existing monitoring wells is specified as an efficient means of collecting first-time data on PFAS basewide for the Former CNC. The plan for obtaining data, along with the sampling designs and rationales, are described in detail in Worksheet #s 17 and 18. This SAP may be modified to include future sampling events if needed.

SAP Worksheet #12: Field Quality Control Samples

(UFP-QAPP Manual Section 2.6.2)

Measurement Performance Criteria Table-Field QC Samples

Revision No: 2

Revision Date: March 21, 2019

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPCs)
Field Duplicate	PFAS	One per 10 field samples	Precision	If both the original and duplicate results are ≥ 2x LOQ, Relative Percent Difference (RPD) must be ≤ 30%.
				If either the original or duplicate result is < 2x LOQ, use professional judgment
Equipment Rinsate Blank (EB)	PFAS	One per 19 field samples per sampling equipment ^(1,2)	Bias/Contamination	No analytes ≥ ½ LOQ.
Field Reagent Blank (FRB)	PFAS	With each aqueous sample set comprising samples collected from the same sample site and at the same time ^(1,3) One per 10 locations basewide.	Accuracy/Bias/ Contamination	Analysis required only if associated field sample PFAS target analyte concentration > LOQ. If target analyte(s) detected in a field sample have FRB concentration >1/3 the LOQ, flag data and review with the Project Team to assess whether samples should be recollected.
Cooler Temperature Indicator	PFAS	One per cooler	Representativeness	Temperature must be above freezing and less than or equal to 10°C during shipment to the laboratory. The laboratory should store the samples at 6°C.
Matrix Spike (MS)/Matrix Spike Duplicate (MSD)	PFAS	One pair per 19 field samples (including field QC samples)	Accuracy/Bias/Precision	See Worksheet #28 for percent recoveries (%Rs) and RPDs

¹ Water used for EBs and FRBs will be PFAS-free water provided by the laboratory.

² Field-cleaned equipment blanks will be collected if any sample equipment decontamination is performed in the field. If no decontamination is performed in the field, pre-cleaned equipment blanks will be collected if the equipment is not certified clean by the vendor or laboratory providing the equipment. Planned EBs are detailed in Worksheet #s 14 and 20.

³ Because the Former CNC project is a basewide evaluation, the entire basewide sample location grouping is considered as the site. However, recognizing the large number of individual sites, one FRB per 10 sample locations is planned for the project for enhanced QC purposes.

SAP Worksheet #13: Secondary Data Criteria and Limitations Table

(UFP-QAPP Manual Section 2.7)

PFASs have not been analyzed for previously at the Former CNC, so prior reports and data sets will not be used for comparative purposes.

Revision No: 1

Date: January 18, 2019

The data collected based on this SAP will provide a baseline data set for use in future PFAS investigations, if necessary.

SAP Worksheet #14: Summary of Project Tasks

(UFP-QAPP Manual Section 2.8.1)

The following project tasks are summarized in this section:

- Mobilization/demobilization
- Sample collection and QC
- Specific sampling methods
- Equipment decontamination
- Investigation-derived waste (IDW) management
- Analytical tasks
- Data management and review tasks
- Reporting

14.1 Field Project Tasks

14.1.1 Mobilization/Demobilization

This subtask involves preparing for field activities and demobilizing from the site upon completion. Following approval of the project plans, Tetra Tech will identify the necessary field support equipment, supplies, and facilities and begin mobilization activities. Two mobilizations are planned. The first will be a reconnaissance site visit to determine and document the planned wells for sampling that do, in fact, have tubing present and to temporarily remove tubing in preparation for the second mobilization for the PFAS sampling event. The reconnaissance site visit and subsequent PFAS sampling will be coordinated with the Navy so as not to interfere with any annual monitoring. For each of the two events, permission will be needed from the various property owners.

Revision No: 1

Date: January 18, 2019

Site mobilization will consist of preparation for field activities and includes, but is not limited to, the following activities:

- Perform all required training or orientation
- Obtain all equipment required to perform field activities
- Identify and prepare locations for all field activities
- Obtain access from the various property owners
- Coordinate sample types, analyses, and sampling schedule with the laboratory

Tetra Tech will prepare a list of all equipment and supplies necessary for the field team to perform the field activities. This list includes but is not limited to:

- All documents, forms, logbooks, logsheets, labels, custody seals, airbills, and other paperwork required by the SAP and APP/HHSP.
- Vehicles for personnel, equipment, and sample transport.
- Personnel and equipment decontamination supplies and equipment required by the SAP and APP/SSHP.
- Media sampling field analytical equipment and calibration standards for all required parameters of the SAP.
- All required sample containers.
- Equipment and supplies for sample custody, preservation, and packaging.
- Other miscellaneous office and field supplies.

As part of demobilization, equipment and supplies will be collected, inventoried, and returned as appropriate. All field investigation paperwork will be filed and docketed in the project file.

Revision No: 1

Date: January 18, 2019

During the required training and orientation, all field team members will review the SAP and will be given site-specific health and safety training based on the APP/SSHP. A field team orientation meeting will be held to familiarize personnel with the scope of field activities. The orientation will include a walking tour of each site and a drive around the main roads of the area to familiarize personnel with the physical layout of each site and adjacent off-site areas.

The field team will obtain the required equipment and supplies from the Tetra Tech warehouse or offices and transport it to and stage it at the base of operations. Any equipment not available at the Tetra Tech warehouse or offices will be purchased or rented by Tetra Tech. Equipment will be calibrated as described in Section 14.1.2. Equipment will be restocked, replaced, or repaired as needed.

Field documentation will be performed in accordance with USEPA Region 4 SOPs SESDPROC-010-R5 and -005-R2 and Tetra Tech SOP SA-6.3. A groundwater sampling log sheet will be maintained for each sample collected. In addition, sample collection information will be recorded in a bound field notebook or on specific field forms in accordance with USEPA Region 4 SOP SESDPROC-301-R4. Samples will be packaged and shipped to the analytical laboratory in accordance with USEPA Region 4 SOP SESDPROC-209-RR3 and Tetra Tech SOP SA-6.3. Field SOPs are provided in Appendix A, and field forms are provided in Appendix B.

A summary of field activities will be properly recorded in a bound logbook with consecutively numbered pages. Logbooks will be assigned to field personnel and stored in a secured area when not in use.

All entries will be written in indelible ink, and no erasures will be made. If an incorrect entry is made, striking a single line through the incorrect information will make the correction; the person making the correction will initial and date the change.

Site demobilization will consist of removing from the site all facilities, supplies, and equipment no longer needed at the end of field work. The base of operations and field work locations will be restored as closely as possible to their original conditions by the field team or responsible subcontractor.

Site-Specific Health and Safety Training

Orientation and site-specific health and safety training will be performed for the field crew as they mobilize at the site. It will also be necessary to provide orientation and health and safety training for any additional or replacement field team members assigned after the initial mobilization.

14.1.2 Sample Collection and QC

Prior to initiating sample collection, field equipment will be calibrated in accordance with USEPA Region 4 SOP SESDPROC-108-R5 and Tetra Tech SOP SA-1.1 by the Tetra Tech FOL or designee. Documentation of field equipment calibration will be conducted in accordance with Tetra Tech SOP SA-6.3. Field equipment will be calibrated at the beginning and end of each day, unless otherwise stated by the equipment manufacturer. See worksheet #22 for calibration specifications.

14.1.3 Specific Sampling Methods

Groundwater samples will be collected from the permanent monitoring wells and drive point listed in Worksheet #18. The drive point will be manually hammered into the ground by hand and purged prior to sampling. After the sample is collected from the hand-driven drive point, it will be pulled out and disposed of in a dumpster.

Many of the planned wells for PFAS sampling are suspected to have dedicated tubing since used routinely for annual monitoring. Some of the planned wells may not have tubing present. A reconnaissance site visit will be conducted to determine and document the planned wells that do in fact have tubing present and to temporarily remove tubing in preparation for the return trip for the PFAS sampling event. The reconnaissance site visit and subsequent PFAS sampling will be coordinated with the Navy so as not to interfere with any annual monitoring. Upon completion of the PFAS sampling event, the removed tubing will be reinserted into its associated monitoring well.

Revision No: 2

Date: March 21, 2019

Sampling will be performed as outlined in Table 14-1 (which addresses groundwater sampling protocols; see Worksheet #21 for a full list of applicable SOPs). Groundwater will be measured in the field for pH, specific conductivity, turbidity, temperature, and DO to determine stabilization; associated SOPs are listed in Worksheet #21.

If sampling equipment (e.g., existing tubing) containing Teflon materials is identified in any of the monitoring wells during the PFAS groundwater screening investigation, the sampling equipment will be removed from the monitoring well and a two-well-volume limited redevelopment will be completed to eliminate cross-contamination with PFAS from previous sampling equipment (following SOP GH-2.8). Equipment used during the redevelopment and decontamination methods employed will follow SOP SA 1.8.

Worksheet #17 provides the sampling design and rationales, and Worksheet #18 provides sample identification information. Sample labeling will be in accordance with Tetra Tech SOP SA-6.1. Methods for sample handling will be in accordance with Tetra Tech SOP SA-1.8. Sample containers will be provided in certified-clean condition from the analytical laboratory. The selection of sample containers, sample preservation, packaging, and shipping will be in accordance with Worksheet #19.

		Table 14- PFAS Sampling Red	•	
Sample Type	Applicable Sampling SOP ⁽¹⁾	Pre-Sampling Requirements	Purge Requirements	Blank Requirements ⁽²⁾
Groundwater from Permanent Monitoring Well or Drive Point	USEPA Region 4 SOP SESDPROC- 301-R4 and Tetra Tech SOP SA-1.8	To minimize cross-contamination from historical groundwater sampling equipment potentially containing Teflon materials, dedicated sample equipment will be removed, as necessary, a minimum of 14 days prior to the PFAS sampling event, and wells will be redeveloped. After the minimum 14-day wait period for recovery, purging and sampling of wells can be initiated. Sampling equipment will be in compliance with SOP SA-1.8.	Purge in accordance with USEPA Region 4 SOP SESDPROC-301-R4.	Per Basewide Effort: 1 EB per 19 field samples per type of sampling equipment One FRB per 10 locations basewide

Table 14-1 PFAS Sampling Requirements									
Sample Type Applicable Sampling SOP ⁽¹⁾ Pre-Sampling Purge Requirements Purge Requirements Requirements ⁽²⁾									
All Other QA/QC Samples ⁽³⁾	All Other Duplicates—1 duplicate sample per 10 field samples QA/QC MS/MSDs—1 MS/MSD sample set per 19 field samples								

Date: March 21, 2019

- 1 Does not include equipment calibration/operation SOPs; see Worksheet # 21 for a full list of field SOPs.
- 2 Blank requirements are consistent with analysis of PFAS by LCMSMS compliant with Quality Systems Manual (QSM) 5.1 Table B-15.
- 3 All other field QC will be in accordance with Worksheet #12.

14.1.4 Equipment Decontamination

Well sampling materials will be decontaminated following the requirements of Tetra Tech SOPs SA 1.8 and 7.1. To the maximum extent possible, Tetra Tech will use dedicated and disposable sampling equipment to avoid the potential for cross-contamination of samples due to inadequate decontamination processes. The dedicated, disposable, sampling equipment will include disposable high-density polyethylene (HDPE) and silicon tubing, disposable gloves, and laboratory-supplied sample bottles.

Non-disposable or non-dedicated sampling equipment (e.g., peristaltic pumps, water level indicators, water quality meters, etc.) will be decontaminated prior to sampling and between samples. Cleaning of equipment is performed to prevent cross-contamination between samples and to maintain a clean working environment for all personnel. Pre-sampling and between sample decontamination will be performed in stainless steel buckets on HDPE sheeting.

Each piece of equipment (including the HDPE and silicon tubing) will be decontaminated prior to use to minimize cross-contamination associated with plastic wrapping and packaging. Decontamination will be conducted at the wellhead, even if the equipment has been decontaminated after its last use. Clean sampling equipment will not be placed directly on the ground or other contaminated surfaces prior to insertion into the well. Decontamination procedures to be used for this project are discussed below.

Because PFAS is a potential site contaminant, final equipment decontamination rinses must be with PFAS-free water. Decontamination water will be containerized. IDW handling procedures will be in accordance with Tetra Tech SOP SA-7.1 and SA-1.8 (see Section 14.1.5).

14.1.5 IDW Management

Aqueous IDW generated during sampling, including decontamination fluids, will be handled in accordance with Tetra Tech SOPs SA-7.1 and SA-1.8. Aqueous IDW will be generated during well development, well purging, groundwater sampling, and decontamination procedures. Aqueous IDW will be contained in polyethylene tanks or Department of Transportation-approved 55-gallon drums. Every effort will be made to minimize the number of drums staged at the Former CNC. The IDW will be appropriately disposed of based on waste characterization results.

In determining waste characterization, PFAS requires additional consideration. PFAS are not RCRA or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous wastes. For this project, IDW samples will be collected for PFAS analysis. Also, the waste manifests will indicate that the waste potentially contains PFAS. For IDW water characterization purposes, a sample will be collected of the IDW and analyzed by the laboratory prior to arranging for IDW disposal. If the combined PFOA and PFAS concentration (i.e., PFOA concentration + PFOS concentration) is less than 70 ng/L, the water will be disposed of if not prohibited by other legally enforceable requirements; otherwise, the water

will be treated to reduce the combined PFOA/PFOS concentration to less than 70 ng/L, which will allow the IDW water to be disposed of within any legally enforceable requirement, with no special handling, treatment, or disposal due to PFOA or PFOS. If IDW results are much greater than 70 ng/L, special actions may be necessary and the RPM will be consulted.

Revision No: 1

Date: January 18, 2019

14.2 ADDITIONAL PROJECT-RELATED TASKS

Additional project-related tasks include:

- Analytical tasks
- Data generation procedures
- Data management tasks
- Data assessment and oversight tasks
- Data review tasks
- Project reports

Analytical Tasks

Chemical analyses will be conducted by Shealy, which has Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accreditation, valid from October 17, 2018 through November 18, 2021. Shealy is accredited to conduct PFAS analysis by LCMSMS compliance with QSM 5.1 Table B-15. A copy of Shealy's certificate of accreditation is provided in Appendix C. Analyses will be performed in accordance with the analytical methods identified in Worksheet #30. Shealy will meet the requirements of technical specification noted in the laboratory project scope of work and the QSM minimum requirements. The laboratory will meet the LOQs specified in Worksheet #15 and will perform the chemical analyses following the laboratory-specific SOP (Worksheet #23) developed based on the method listed in Worksheet #19. The laboratory SOPs are provided as Appendix D.

Laboratory data will be delivered to Tetra Tech in the form of an electronic data deliverable (EDD). This information will be included in the project database that will eventually be uploaded to NIRIS.

Data Handling and Management—After the field investigation is completed, the field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after the completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity. The data-handling procedures to be followed by the laboratory will meet the requirements of the technical specification noted in the laboratory project scope. The electronic data results will be automatically downloaded into the Tetra Tech database in accordance with proprietary Tetra Tech processes.

Data Tracking—Data will be tracked from generation to archiving in the Tetra Tech project-specific files. The Tetra Tech Project Chemist (or designee) will be responsible for tracking the samples collected and shipped to the subcontracted laboratory. Upon receipt of the data packages from the analytical laboratory, the Tetra Tech Project Chemist will coordinate the data verification and validation efforts described in Worksheets #34 through #36.

Data and Records Storage, Archiving, and Retrieval—After the data are validated, the data packages are entered into the Tetra Tech Navy CLEAN file system and archived in secure files. The field records including field logbooks, sample log sheets, chain-of-custody records, and field calibration logs will be submitted by the Tetra Tech FOL to be entered into the Navy CLEAN file system prior to archiving in secure project files. As documents are finalized, all relevant data and records are uploaded electronically to NIRIS and retained there indefinitely. Tetra Tech will submit Administrative Record Files, Site Files, and Post Decision Files in accordance with the specifications defined in the NAVFAC *Environmental Restoration Program*

Recordkeeping Manual (2017). Upon project completion, paper copies are submitted to the Federal Record Center for long-term storage (50 years archival).

Revision No: 1

Date: January 18, 2019

Data Security—The Tetra Tech project files are restricted to designated personnel only. Records may only be borrowed temporarily from the project file using a sign-out system. The Tetra Tech Data Manager maintains the electronic data files. Access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

Electronic Data— All electronic results will be verified against the laboratory hardcopy data package for accuracy. All (100 percent) of the electronic data are validated, and qualifiers are manually added to the database. The manually entered qualifiers are verified by the DVM or designee and via an electronic verification step using proprietary Tetra Tech processes. Data will then be compiled into a NIRIS Electronic Data Deliverable (NEDD) and loaded into NIRIS in accordance with Navy procedures. This process includes a QA review of the data to ensure that the content and format of the data satisfy the requirements of NIRIS uploads. The NEDD is submitted through a data checker into NIRIS, which also ensures that the format is acceptable.

Data Review

Data verification, validation, and usability assessment processes are described on Worksheet #s 34 through 37.

Project Reports

At the completion of data review and resolution of anomalies, should they occur, a project report will be prepared to present results of the investigation and satisfy DQOs, as identified in Worksheets #10 and #11. The anticipated deliverable for this project is a Sampling Summary Report that will provide details regarding the groundwater sampling event, including all analytical data generated from the samples. The Sampling Summary Report will also include a section that will identify deviations from the approved SAP, should any occur, and all completed field forms will be provided as appendices.

Data evaluation and site management decisions will be based on the DQOs for the site, which are described in Worksheet #11.

The draft report will be submitted to the Navy and DHEC for comments and approval. Responses to comments and necessary revisions will be made to the draft report before issuing a final report, and responses to comments will be managed similar to other project records. Project documents and records generated during the course of project activities (e.g., calibration logs, health and safety certificates, etc.) are identified in Worksheet #29. The Final report will be uploaded to NIRIS.

SAP Worksheet #15: Reference Limits and Evaluation Tables

(UFP-QAPP Manual Section 2.8.1)

Analyte	CAS Number	PAL ⁽¹⁾ (ng/L)	PAL Reference ⁽²⁾	PQLG ⁽³⁾ (ng/L)	Labo	ratory L (ng/L) ⁽⁴⁾	imits
		(lig/L)	IXelefelice.	(lig/L)	LOQ	LOD	DL
	PFAS (2) in Gro	undwater					
Perfluorooctanesulfonic Acid (PFOS)	1763-23-1	70 ⁵	USEPA HA	23	4	2	1
Perfluorooctanoic Acid (PFOA)	335-67-1	70 ⁵	USEPA HA	23	4	2	1
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	380,000	Tap water RSL	130,000	4	2	1
Perfluorodecanoic Acid (PFDA)	335-76-2	NC			4	2	1
Perfluorododecanoic Acid (PFDoA)	307-55-1	NC			4	2	1
Perfluoroheptanoic Acid (PFHpA)	375-85-9	NC			4	2	1
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	NC			4	2	1
Perfluorohexanoic Acid (PFHxA)	307-24-4	NC			4	2	1
Perfluorononanoic Acid (PFNA)	375-95-1	NC			4	2	1
Perfluorotetradecanoic Acid (PFTA)	376-06-7	NC			8	4	2
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	NC			4	2	1
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	NC			4	2	1
N-methyl perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	2355-31-9	NC			8	4	2
N-ethyl perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	NC			16	8	4

Revision No: 1

Revision Date: January 18, 2019

- 1 If screening levels change prior to the field event, Worksheet #15 will be amended via a SAP Amendment to document the changes to screening levels. If screening levels change after the field event begins, Worksheet #15 will be amended via an FTMR.
- 2 Groundwater samples will be analyzed for PFAS by LCMSMS compliant with the *Department of Defense Quality Systems Manual for Environmental Laboratories*, Version 5.1, Table B-15 (DoD, 2017).
- 3 The Practical Quantitation Limit Goal (PQLG) is approximately one-third of the PAL.
- 4 Laboratory-specific DLs, Limits of Detection (LODs), and LOQs provided by Shealy.
- 5 USEPA's drinking water HAs for PFOS and PFOA state that when PFOS and PFOA "co-occur at the same time and location in a drinking water source, a conservative and health-protective approach...is to compare the sum of the concentrations" (PFOA + PFOS) to the HA of 70 ng/L (USEPA, 2016a through 2016e).

CAS = Chemical Abstracts Services.

HA = Health Advisories for PFOA and PFOS (USEPA, 2016a; 2016b; and 2016c).

NC = No criterion.

Tapwater RSL = USEPA RSL (2017). Value based on hazard quotient of 1.

SAP Worksheet #16: Project Schedule/Timeline Table

(UFP-QAPP Manual Section 2.8.2)

Activity	Number of Days from Start	Duration	Deliverable	Deliverable Due Date
Groundwater Sampling Fieldwork and Report Generation	Tetra Tech	Field Work - Initiate within 30 Days of SAP Approval or as Otherwise Instructed by the NAVFAC RPM Complete field work within 6 days of initiation	Technical Memorandum	Submit Internal Draft Report within 90 Days of Field Work Completion Submit Draft Report within 30 Days of Comment Receipt Submit Final Report within 30 Days of Comment Receipt

Revision No: 1

Revision Date: January 18, 2019

The Project Chemist will ensure that laboratory accreditation is valid for the duration of laboratory analytical work.

SAP Worksheet #17: Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)

17.1 Sampling Approach

The sampling design is a biased design developed to optimize resources and generate data to satisfy the DQOs. Existing permanent monitoring wells will be sampled in areas where PFAS could have potentially been released to the environment. Table 10-1 identifies the permanent monitoring wells proposed for sampling and associated rationales for their selection. At one of the locations, where there are no nearby existing monitoring wells, a groundwater sample will be collected using a hand-driven drive point. Groundwater samples will be collected for analysis of PFAS as identified in Worksheet #18. Figure 10-1 shows the locations selected for this investigation, which were selected based on historical use and considering groundwater flow directions.

Revision No: 1

Date: January 18, 2019

17.2 Groundwater Sampling

To minimize cross-contamination equipment and construction material containing Teflon will be avoided, and special precautions will be taken when preparing for groundwater sampling. Project-specific precautions are described in detail in Worksheet #14, USEPA Region 4 SOP SESDPROC-301-R4, and Tetra Tech SOP SA-1.8.

Groundwater sampling will be performed as follows:

- For permanent monitoring wells, dedicated tubing will be removed from the wells, as necessary, 14 days prior to the PFAS sampling event. The monitoring wells with tubing will undergo a limited redevelopment, prior to sampling.
- Peristaltic pumps will be used to collect groundwater samples.

Groundwater samples will be submitted for PFAS analyses to Shealy, including concentrations of both linear and branched isomers. Specific sample identification nomenclature, required sample containers, sample volumes, preservation methods, holding times, and required field QC samples are specified in Worksheet #s 18 and 19.

SAP Worksheet #18: Location-Specific Sampling Methods/SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Sampling Location / ID Numbers	Source Area Owner and Zone	Sample Location Well Owner and Zone	Potential PFAS Source (Abbreviated Summary)	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
H659GW009R/H659GW009R - MMDDYY	U.S. Federal Enclave, Zone H	U.S. Federal Enclave, Zone H	SWMU 13 Fire Training Area and Facilities within SWMU 13 including 1302, 1303, 1309, 1310, 1308, and 1834. Facility 1715 GS Tech Maintenance Shop.	Groundwater	10 feet below ground surface (bgs)	PFAS	1 + 1 Dup	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
H017GW006/H017GW006-MMDDYY	U.S. Federal Enclave, Zone H	U.S. Federal Enclave, Zone H	SWMU 13 Fire Training Area and Facilities within SWMU 13 including 1302, 1303, 1309, 1310, 1308, and 1834. Facility FBM- 61maintenance and used waste oil storage, SWMU 17 Oil Spill Area, and Facility 1891 Bachelor Enlisted Quarters (BEQ) maintenance.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
IN28G35W1/IN28G35W1-MMDDYY	U.S. Federal Enclave, Zone H	U.S. Federal Enclave, Zone I	Facility FBM-61 maintenance and used waste oil storage, SWMU 17 Oil Spill Area, and Facility 1891 large BEQ maintenance.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
I680GW004/I680GW004-MMDDYY	U.S. Federal Enclave, Zones H and I	U.S. Federal Enclave, Zone I	Fire fighting School (and AOC 678 Fire Training Area and AOC 679 wash rack). X-33A (and SWMU 178 Transformer Fire) and adjacent Facility NS-53 hangar/manufacturing shop/maintenance shop.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8

Revision No: 1

Sampling Location / ID Numbers	Source Area Owner and Zone	Sample Location Well Owner and Zone	Potential PFAS Source (Abbreviated Summary)	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
			Tank 14 tank with foam suppression system.					
I12TEMP1/I12TEMP1-MMDDYY	Charleston County Park and Recreational Commission, Zone I	Charleston County Park and Recreational Commission, Zone I	SWMU 12 Former Fire fighter Training Area.	Groundwater	3 to 4 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
H009GW011/H009GW011-MMDDYY	U.S. Federal Enclave, Zone H	U.S. Federal Enclave, Zone H	Facility 672 vehicle and truck maintenance and burning dump area (SWMU 9).	Groundwater	10 feet below ground surface	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
FU25GW012/FU25GW012-MMDDYY	Palmetto Railways, Zone F	Palmetto Railways, Zone F	Fire Station Number 1 and Fire Station Support Building. Facility 1346 gasoline station, automotive repair/maintenance, and waste oil.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
FGELGW012/FGELGW012-MMDDYY	Palmetto Railways, Zone F	City of North Charleston, Zone E	Fire Station Number 1 and Fire Station Support Building. Facility 241 (and associated SWMU 111, 112, 113, and 114 and AOC 713) crane maintenance, paint booth, wash racks, oil water separator (OWS), petroleum, oil and lubricant (POL) storage. Facility 242 (and associated SWMU 115, AOC 614, AOC 613, 714, and 717 large locomotive	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8

Sampling Location / ID Numbers	Source Area Owner and Zone	Sample Location Well Owner and Zone	Potential PFAS Source (Abbreviated Summary)	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
			and crane maintenance and repair, spray paint booth, miscellaneous shops including plate shop, POL storage, wash rack. Four oil/waste oil AST.					
FFDSGW15C/FFDSGW15C - MMDDYY	Palmetto Railways, Zone F	Palmetto Railways, Zone G	SWMU 24 Oil Reclamation Facility, OWS and treatment, aboveground storage tanks (ASTs), waste oil transfer station, and fire foam suppression system.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
E065GW008/E065GW008-MMDDYY	CMMC LLC, Zone E	CMMC LLC, Zone E	SWMU 23 Plating Shop wastewater treatment plan (WWTS) and Former Sludge Pit, Facility 226 (aka Facility 3-A, and SWMU 22 Old Plating Shop Waste Treatment System, and SWMU 25 Old Plating Operation), two OWSs, and AST. Also in area, Building 56 Outside Machine Shop electrical/mechanical group shops to east. Fire Station Number 2.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
	Palmetto Railways, Zone C		Fire Station Number 2. Facility 1079 hazardous/flammable storage building and Facility 1001 POL storage.					

Sampling Location / ID Numbers	Source Area Owner and Zone	Sample Location Well Owner and Zone	Potential PFAS Source (Abbreviated Summary)	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
E025GW003/E025GW003-MMDDYY	Palmetto Railways, Zone C	CMMC LLC, Zone E	Fire Station Number 2. Facility 1079 hazardous/flammable storage building and Facility 1001 POL storage.	Groundwater	10 feet bgs	PFAS	1 + 1 Dup	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
	CMMC LLC, Zone E	CMMC LLC, Zone E	SWMU 87 Less than 90 Day Accumulation Area, SWMU 172 Building 80 Steam Cleaning Operations (was closed landfill and former repair/manufacture of ship propellers, machine shop), AOC 564 OWS and 300 gallon UST, AOC 576 former indoor oil and paint storehouse. AOC 666 waste oil UST.					USEPA
E172GW001/E172GW001-MMDDYY	Palmetto Railways, Zone E		AOC 578 (Facility 25) Former transportation shop and auto maintenance, AOC 569 (Facility 30) former gasoline station and oil storage area, AOC 571 (Facility 177) former paint booth, AOC 572 (Facility 177) former motor area, and AOC 723 OWS. Former various shop areas including paint shop and electrical maintenance and paint booth for furniture refinishing. Satellite accumulation area for waste oils and	Groundwater	10 feet bgs	PFAS	1	Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8

Sampling Location / ID Numbers	Source Area Owner and Zone	Sample Location Well Owner and Zone	Potential PFAS Source (Abbreviated Summary)	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
			aerosol cans. Also, 2 waste oil USTs.					
E569GW005/E569GW005-MMDDYY	Palmetto Railways, Zone E	City of North Charleston, Zone E	AOC 578 (Facility 25) former transportation shop and auto maintenance, AOC 569 (Facility 30) former gasoline station and oil storage area, AOC 571 (Facility 177) former paint booth, AOC 572 (Facility 177) former motor area, and AOC 723 OWS. Former various shop areas including paint shop and electrical maintenance and paint booth for furniture refinishing. Satellite accumulation area for waste oils and aerosol cans. Also, two waste oil underground storage tanks (USTs).	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
GF08GW08A/GF08GW08A - MMDDYY	Palmetto Railways, Zone G	Palmetto Railways, Zone G	Hobson Fuel Farm ASTs, pumphouse, and fire foam suppression system. Fire Station Number 3. AOC 733 Chicora Tank Farm USTs and AST, stormwater drainage	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1
	Charleston, Zone G		detention pond, and fire foam suppression system.					and SA-1.8

Sampling Location / ID Numbers	Source Area Owner and Zone	Sample Location Well Owner and Zone	Potential PFAS Source (Abbreviated Summary)	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
G633GW005/G633GW005-MMDDYY	Palmetto Railways, Zone G	Charleston Naval Complex, Zone G	Hobson Fuel Farm ASTs, pumphouse, and fire foam suppression system. Fire Station Number 3.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
H009GW023/H009GW023-MMDDYY	City of North Charleston, Zone G	U.S. Federal Enclave, Zone H	AOC 733 Chicora Tank Farm USTs and AST, stormwater drainage detention pond, and fire foam suppression system.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
FFDSGW04/FFDSGW04-MMDDYY	Charleston Naval Complex, Zone G	Charleston Naval Complex, Zone G	SWMU 8 Oil Sludge Pit and Facility 161, and AOC 637 Dump Area	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
Various, described elsewhere in table/ Various	Charleston Naval Complex and U.S. Federal Enclave, Zones G and H	Various, described elsewhere in table	SWMU 8, Facility 672, SWMU 13, SWMU 20, and SWMU 196 which will provide PFAS information on SWMU 9, closed 120-acre landfill.	Groundwater	10 feet bgs	PFAS	NA	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
H009GW014/H009GW014-MMDDYY	U.S. Federal Enclave, Zone H City of North Charleston, Zone G	U.S. Federal Enclave, Zone H	SWMU 20 waste disposal area. AOC 733 Chicora Tank Farm	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8

Sampling Location / ID Numbers	Source Area Owner and Zone	Sample Location Well Owner and Zone	Potential PFAS Source (Abbreviated Summary)	Matrix	Depth	Analytical Group	Number of Samples	Sampling SOP Reference
E605GW04R/E605GW04R-MMDDYY	CNC Redevelopme nt, Zone E Clemson Univ., Zone E	CNC Redevelopment, Zone E	SWMU 18 Polychlorinated biphenyl (PCB) Spill Area at Facility 1278. Facility 69 and 69A Warehouse (with forklift maintenance and repairs), AOC 616 Paint Shop, and AOC 617 Galvanizing Shop. Facility 1824 hazardous/flammable storage including plating solutions and petroleum products, and AOC 619 former oil storage yard.	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
DGDDGW001/DGDDGW001- MMDDYY	Palmetto Railways, Zone D	Palmetto Railways, Zone D	Facility 1501 truck fleet maintenance center Facility 1509 maintenance, repair, and storage.	Groundwater	10 feet bgs	PFAS	1+ 1 Dup	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
MW-2R/MW-2R-MMDDYY	City of North Charleston, Zone G	City of North Charleston, Zone G	Chicora Tank Farm	Groundwater	10 feet bgs	PFAS	1	USEPA Region 4 SOP SESDPROC- 301-R4 Tetra Tech SOPs SA-1.1 and SA-1.8
Field QC Samples ¹								
Field Duplicate/ XX-FD-MMDDYY-X ⁽¹⁾	NA	NA	NA	Aqueous QA	NA	PFAS	2	USEPA Region 4 SOP
FRB/ XX-FRB-MMDDYY-X ⁽¹⁾	NA	NA	NA	Aqueous QA	NA	PFAS	2	SESDPROC- 301-R4
EB/ XX-EB-MMDDYY-X ⁽¹⁾	NA	NA	NA	Aqueous QA	NA	PFAS	3	Tetra Tech SOPs SA-1.1
MS/MSD / Same ID as sample	NA	NA	NA	Aqueous QA	NA	PFAS	1/1	and SA-1.8

Revision Date: January 18, 2019

Revision No: 1

Field QC counts may change depending on duration and details of the field event. 1

MW = TW

Monitoring Well.
Temporary Well.
Month (MM), day (DD), year (YY), (e.g., 073018 for 30 July 2018).
Incremental number of equipment blank (e.g., 1, 2, 3).

MMDDYY = X =

SAP Worksheet #19: Field Sampling Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type)	Sample Volume (units)	Preservation Requirements (chemical, temperature, light protected) (1)	Maximum Holding Time ⁽²⁾ (preparation/ analysis)
Groundwater	PFAS	PFAS by LCMSMS compliant with QSM 5.1 Table B- 15 /Shealy SOP ME00213	Two 250-milliliter (mL) HDPE bottles with unlined polypropylene caps	250 mL	Temperature must be above freezing and less than or equal to 10 °C during shipment to the laboratory. The laboratory should store samples at 6°C.	14 days from collection to extraction/28 days from extraction to analysis

Revision No: 1

For PFAS sampling, samples with temperatures significantly greater than 10° C at the time of collection may need to be iced or refrigerated for a period of time to chill them prior to shipping. This will allow them to be shipped with sufficient ice to meet the preservation requirements.

² Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

SAP Worksheet #20: Field Quality Control Sample Summary Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs (2,3)	No. of FRBs ^(1,3)	No. of EBs ^(1,3)	No. of Trip Blanks	No. of Proficiency Testing Samples	Total No. of Samples to Lab
Groundwater	PFAS	19	2	1/1	2	3	0	0	28

Revision No: 2

Revision Date: March 21, 2019

- 1 PFAS-free water to be used EBs and FRBs will be provided by the laboratory.
- 2 Although MS/MSD samples are not typically considered field QC samples, they are included in the "Total No. of Samples to Lab." Each MS/MSD pair is counted as one sample.
- 3 Field QC counts may change depending on duration and details of the field event.

SAP Worksheet #21: Project Sampling SOP References Table

(UFP-QAPP Manual Section 3.1.2)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SESDPROC-005- R2	Sample and Evidence Management, 01/29/13, Rev. 2	USEPA	NA	No	Appendix A
SESDPROC-010- R5	Logbooks, 05/30/13, Rev. 5	USEPA	NA	No	Appendix A
SESDPROC-011- R5	Field Sampling Quality Control, 04/26/17, Rev. 5	USEPA	NA	No	Appendix A
SESDPROC-100- R4	Field pH Measurement, 12/16/16, Rev. 4	USEPA	pH meter	No	Appendix A
SESDPROC-101- R6	Field Specific Conductance Measurement, 07/13/16, Rev. 6	USEPA	Specific conductance meter	No	Appendix A
SESDPROC-102- R4	Field Temperature Measurement, 10/23/14, Rev. 4	USEPA	Thermistor, thermometer, or temperature sensor	No	Appendix A
SESDPROC-103- R4	Field Turbidity Measurement, 07/27/17, Rev. 4	USEPA	Turbidity sensor	No	Appendix A
SESDPROC-105- R3	Groundwater Level and Well Depth Measurement, 11/03/16, Rev. 3	USEPA	Electronic water level indicator	No	Appendix A
SESDPROC-106- R4	Field Measurement of Dissolved Oxygen, 04/12/17, Rev. 4	USEPA	DO sensor	No	Appendix A
SESDPROC-108- R5	Equipment Inventory and Management, 08/13/15, Rev. 5	USEPA	NA	No	Appendix A
SESDPROC-110- R4	Global Positioning System, 06/23/15, Rev. 4	USEPA	GPS equipment (to locate existing wells)	No	Appendix A
SESDPROC-111- R3	In-Situ Water Quality Monitoring, 07/19/13, Rev. 3	USEPA	Multi-parameter water quality meter	No	Appendix A

Revision No: 1

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SESDPROC-113- R2	Field Measurement of Oxidation- Reduction Potential (ORP), 04/26/17, Rev. 2	USEPA	ORP meter	No	Appendix A
SESDPROC-202- R3	Management of Investigation Derived Waste, 07/03/14, Rev. 3	USEPA	NA	No	Appendix A
SESDPROC-203- R3	Pump Operation, 09/12/13, Rev. 3	USEPA	Peristaltic pump	No	Appendix A
SESDPROC-205- R3	Field Equipment Cleaning and Decontamination, 12/18/15, Rev. 3	USEPA	Decontamination equipment (scrub brushes, phosphate-free detergent, deionized water)	No	Appendix A
SESDPROC-209- R3	Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, 02/04/15, Rev. 3	USEPA	Sample bottle ware, packaging material, shipping materials	No	Appendix A
SESDPROC-301- R4	Groundwater Sampling, 04/26/17, Rev. 4	USEPA	Peristaltic pump	No	Appendix A
SOP SA-6.3	Field Documentation, 09/28/17, Rev. 6	Tetra Tech	Field log book and log sheets	No	Appendix A
SOP SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing, 07/15/16, Rev. 9	Tetra Tech	Peristaltic pump, turbidity meter, water quality meter,	No	Appendix A
SOP GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement, 02/17/16, Rev. 4	Tetra Tech	Electric water level indicator	No	Appendix A
SOP CT-04	Sample Nomenclature, 11/20/16, Rev. 5	Tetra Tech	NA	No	Appendix A
SOP SA-7.1	Decontamination of Field Equipment and Management of Investigation Derived Waste, 07/15/16, Rev 8	Tetra Tech	Liquinox	No	Liquinox will be used as the detergent and acid-rinse steps will be omitted. Appendix A

	Revision No: 1
Revision Date: Ja	nuary 18, 2019

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
SOP SA -1.8	Sample Acquisition for Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) Analysis, 01/25/18, Rev 3	Tetra Tech	NA	No	Appendix A

Field SOPs are provided in Appendix A.

SAP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity	Frequency	Acceptance Criteria	CA	Resp. Person	SOP Reference	Comments
Water Quality Meter YSI 556 (or equivalent)	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Temperature: Calibration performed by equipment provider. pH: ± 0.2 Standard Units Specific Conductance: ± 5.0% of reading DO: ±0.3 milligrams per liter (mg/L)	Operator correction or replacement	FOL or Designee	Manufacturer's Guidance Manual	Batteries Calibration solutions
Turbidity Meter Hach 2100Q (or equivalent)	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	The acceptance criterion for the initial calibration verification (ICV) depends on the range of turbidity values of the standard value, as follows: 0.1 to 10 NTUs: within 10% of the standard value 11 to 40 NTUs: within 8% of the standard value 41 to 100 NTUs: within 6.5% of the standard value >100 NTUs: within 5% of the standard value	Operator correction or replacement	FOL or Designee	Manufacturer's Guidance Manual	Batteries
Water Level Indicator	Visual Inspection Field checks per manufacturer	Daily Once upon receiving from vendor	0.01-foot accuracy	Operator correction or replacement	FOL or Designee	Manufacturer's Guidance Manual	Batteries
GPS	Positioning to locate existing wells	NA	NA	Wait for better signal, replace unit, or choose alternate location technique	FOL or Designee	Manufacturer's Guidance Manual and SESDPROC- 110-R4	Battery Pack Spare stylus and tether

Revision No: 1

SAP Worksheet #23: Analytical SOP References Table

(UFP-QAPP Manual Section 3.2.1)

Laboratory SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to Quality Systems Manual (QSM)? (Y/N)	Modified for Project Work? (Y/N)
ME00213	Determination of Per- and Polyfluoroalkyl Substances (PFAS) by LC/MS/MS (Isotope Dilution) QSM 5.1 Table B-15 (EPA 537 MOD ID) 06/20/2018, Rev. 8	Definitive	Groundwater PFAS	Liquid Chromatography/ Tandem Mass Spectrometry (LCMSMS)	Shealy	N	N
ME0012K	Quality Assurance Management Plan (QAMP) 07/28/2017, Rev. 5	Definitive	All	NA	Shealy	N	N
ME0013H	Sample Receiving 05/08/2018, Rev. 8	Definitive	All	NA	Shealy	N	N

Revision No: 1

SAP Worksheet #24: Analytical Instrument Calibration Table

(UFP-QAPP Manual Section 3.2.2)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS – PFAS	Aqueous Sample Preparation	Each sample and associated batch QC samples.	Solid Phase Extraction (SPE) must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable.	NA	Analyst	ME00213
			Samples of known high PFAS concentrations can be prepared by serial dilution instead of SPE, with documented project approval.			
LC/MS/MS – PFAS	Sample Cleanup Procedure using ENVI-Carb or equivalent	Each sample and associated batch QC samples. Not applicable to AFFF formulation samples.	Removal of interferences from matrix. Cleanup should reduce bias from matrix background	NA. Flagging is not appropriate.	Analyst	ME00213
LC/MS/MS – PFAS	Mass calibration	Initially prior to use and after performing major maintenance, as required to maintain documented instrument sensitivity and stability performance.	Calibrate the mass scale of the mass spectrometer with calibration compounds and procedures described by the manufacturer. Entire range needs to be mass calibrated.	NA. Flagging is not appropriate.	Analyst	ME00213
LC/MS/MS – PFAS	Tune check	When the masses fall outside of ±0.5 atomic mass unit (amu) of true value (as determined by	Mass assignments of tuning standard within 0.5 amu of true value. No samples will be analyzed without a valid tune.	Retune instrument and verify. If the tuning will not meet acceptance	Analyst	ME00213

Revision No: 1

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
		product ion formulas).		criteria, an instrument mass calibration must be performed and the tune check repeated. Flagging is not appropriate.		
LC/MS/MS – PFAS	Mass spectral acquisition rate	Each analyte, extracted internal standard analyte, and injection internal standard analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	NA. Flagging is not appropriate.	Analyst	ME00213
LC/MS/MS – PFAS	Calibration, calibration verification, and spiking standards Standards containing both branched and linear isomers are to be used during method validation to ensure that the total response is quantitated for that analyte. Technical grade standards cannot be used for quantitative analysis.	All analytes.	Standards containing both branched and linear isomers must be used when commercially available. If not available, the total response of the analyte must be integrated (i.e., accounting for peaks that are identified as linear and branched isomers) and quantitated using a calibration curve that includes the linear isomer only for that analyte (e.g., PFOA).	NA. Flagging is not appropriate.	Analyst	ME00213
LC/MS/MS – PFAS	Ion Transitions (Parent-> Product)	Prior to method implementation.	The chemical derivation of the ion transitions, both those used for quantitation and those used for confirmation, must be documented. Two transitions and the ion transition ratio per	NA. Flagging is not appropriate.	Analyst	ME00213

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
			analyte will be monitored and documented with the exception of PFBA and PFPeA.			
			To avoid biasing results high due to known interferences for some transitions, the following transitions must be used for quantification of the following analytes: PFOA: 413 → 369 PFOS: 499 → 80 PFHXS: 399 → 80 PFHXS: 399 → 80 4:2 Fluorinated telomer sulfonate (FTS): 327 → 307 6:2 FTS: 427 → 407 8:2 FTS: 527 → 507 NEtFOSAA: 584 → 419 NMeFOSAA: 570 → 419 If these transitions are not used, the reason must be			
			technically justified and documented (e.g., alternate transition was used due to observed interferences).			
LC/MS/MS – PFAS	Initial Calibration (ICAL)	At instrument set-up and ICV or continuing calibration verification (CCV) failure, prior to sample analysis.	The isotopically labeled analog of an analyte (extracted internal standard analyte) must be used for quantitation if commercially available (isotope dilution quantitation).	Correct problem then repeat ICAL. Flagging is not appropriate.	Analyst	ME00213

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
		No samples will be analyzed until ICAL has passed. Isotope dilution or internal standard calibration is required for all analytes. External calibration is not allowed. Calibration can be linear (minimum of five standards) or quadratic (minimum of six standards); weighting is allowed.	If a labeled analog is not commercially available, the extracted internal standard analyte with the closest retention time to the analyte must be used for quantitation. (internal standard quantitation) Signal/noise Ratio: ≥ 10:1 for all ions used for quantification. For analytes having a promulgated standard, (e.g., HAs for PFOA and PFOS), the qualitative (confirmation) transition ion must have an S/N Ratio of ≥ 3:1. The % relative standard deviation (RSD) of the retention factors for all analytes must be <20%. Linear or non-linear calibrations must have r² ≥ 0.99 for each analyte. Analytes must be within 70-130% of their true value for each calibration			
LC/MS/MS – PFAS	Instrument sensitivity check (ISC)	Prior to analysis and at least once every 12 hours. No samples will be analyzed until ISC has met acceptance criteria.	standard. Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values.	Correct problem, rerun ISC. If problem persists, repeat ICAL. Flagging is not appropriate.	Analyst	ME00213

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
		ISC can serve as the initial daily CCV.			-	
LC/MS/MS – PFAS	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis. No samples will be analyzed until calibration has been verified.	Analyte concentrations must be within ± 30% of their true value.	Correct problem, rerun ICV. If that fails, repeat ICAL. Flagging is not appropriate.	Analyst	ME00213
LC/MS/MS - PFAS	CCV	Prior to sample analysis, after every 10 field samples, and at the end of the analytical sequence. Results may not be reported without valid CCVs. ISC can serve as a bracketing CCV.	Concentrations of analytes must range from the LOQ to the mid-level calibration concentration. Analyte concentrations must be within ±30% of their true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, or if two consecutive CCVs cannot be run, perform CA(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV. If reanalysis cannot be	Analyst	ME00213

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
				must be qualified and explained in the Case Narrative.		
				Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification.		

SAP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

(UFP-QAPP Manual Section 3.2.3)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference
LC/MS/MS	Check column pressure and mobile phase levels/expirations daily. Perform the following as needed: prepare aqueous mobile phase, clean/replace injection needle, replace guard cartridge, backflush/replace column, replace injector seat, clean skimmer cone, clean mass spectrometer, retune mass spectrometer	PFAS	Inspect all tubing connections at time of maintenance to assure no leaks present. Monitor instrument performance via calibrations, CCVs, and blanks	Initially, after major maintenance, and CCV not meeting 2X	Same as ICAL and CCV	Same as ICAL and CCV	Analyst/ Supervisor	ME00213

Revision No: 1

SAP Worksheet #26: Sample Handling System

(UFP-QAPP Manual Appendix A)

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT

Sample Collection (Personnel/Organization): FOL or field technician/Tetra Tech

Sample Packaging (Personnel/Organization): FOL or field technician/Tetra Tech

Coordination of Shipment (Personnel/Organization): FOL or field technician/Tetra Tech

Type of Shipment/Carrier: Commercial courier service

SAMPLE RECEIPT AND ANALYSIS

Sample Receipt (Personnel/Organization): Sample Custodian/Shealy

Sample Custody and Storage (Personnel/Organization): Sample Custodians/Shealy

Sample Preparation (Personnel/Organization): Organic Preparation Personnel/Shealy

Sample Determinative Analysis (Personnel/Organization): Organic Preparation Personnel/Shealy

SAMPLE ARCHIVING

Field Sample Storage (No. of days from sample collection): 60 Days from Receipt of Samples

Sample Extract/Digestate Storage (No. of days from extraction/digestion): 3 months from sample digestion/extraction

Biological Sample Storage (No. of days from sample collection): NA

SAMPLE DISPOSAL

Personnel/Organization: Sample Custodians/Shealy

Revision No: 1

SAP Worksheet #27: Sample Custody Requirements

(UFP-QAPP Manual Section 3.3.3)

The following sections outline the procedures that will be used to document project activities and sample collection, handling, tracking, and custody procedures during the investigation. All forms must be filled in as completely as possible.

Revision No: 1

Date: January 18, 2019

27.1 Sample Nomenclature

Sample labeling will be conducted in general accordance with the procedures outlined in Tetra Tech SOP CT-04 (Appendix A). The sample nomenclature includes the site being investigated, sample location number, and sample date.

Sample nomenclature for the PFAS investigation is summarized in Worksheet #18. Duplicate samples will be submitted with "FD" in the sample identifier (e.g., XX-FD-MMDDYY-X). The field QC blank codes that will be used are FRB for field reagent blanks and EB for equipment blanks. XX represents the incremental number (01, 02, etc.) of collection for a given duplicate or other type field QC sample. Samples to be used for MS/MSD samples will be labeled "MS/MSD" on the container label and noted on the chain-of-custody form; however, "MS/MSD" will not be part of the unique sample identifier to maintain consistency with the project database. Worksheet #18 provides anticipated sample identifiers for this project.

27.2 Sample Collection and Documentation

Documentation of field observations will be recorded in a field logbook and/or on field log sheets including daily field forms and sample collection logs. These documents will be used to record information about each sample, including the sample identification number, sample time and date, location, sample matrix, and analytical matrix. Field sample log sheets will be used to document sample collection details and other observations, and activities will be recorded in the field logbook. Instrument calibration logs will be used to record daily instrument calibration.

For sampling and field activities, the following types of information will be recorded in the field logbook and/or on field forms as appropriate:

- Site name and location
- · Date and time of logbook entries
- Personnel and their affiliations
- Weather conditions
- Activities involved with sampling
- Subcontractor activity summaries
- Site observations including site entry and exit times
- Site sketches made on site
- Visitor names, affiliations, and arrival and departure times
- Health and safety issues, including personal protective equipment

27.3 Sample Packaging and Shipping

Samples will be prepared for shipping in accordance with Tetra Tech SOP SA-1.8 and managed under strict chain of custody (see Section 27.5).

27.4 Sample Handling and Tracking System

The laboratory will provide clean sample containers for sample collection. Tetra Tech personnel will collect the samples, and samplers will take care not to contaminate samples through improper handling. As indicated on Worksheet #19, samples will be maintained at less than or equal to 10°C until delivery to the

laboratory. Proper custody procedures will be followed throughout all phases of sample collection and handling.

Revision No: 1

Date: January 18, 2019

Following collection, all samples will be immediately placed on ice in a cooler. The sample containers will be enclosed in bubble-wrap to protect the bottle ware during shipment. Samples will be packed with wet ice in each cooler. A temperature blank (a small polypropylene bottle or 40-mL vial filled with deionized water) will be placed in each cooler to determine the core temperature of the samples received by the laboratory technician. The cooler will be secured using packing tape along with signed custody seals. One copy of the chain-of-custody form will be placed in each cooler.

After collection, each sample will be maintained in the sampler's custody until formally transferred to another party (e.g., commercial courier). The samples will then remain in the custody of the commercial courier until they reach the laboratory and the location of the sample cooler(s) will be tracked by the Tetra Tech Project Manager or designee via the commercial courier's tracking number. For all samples collected, chain-of-custody forms will document the date and time of sample collection, sampler's name, and names of all others who subsequently held custody of the sample. Specifications for chemical analyses will also be documented on the chain-of-custody form. Tetra Tech SOP SA-6.3 (Appendix A) provides further details on chain-of-custody procedures.

Once received by the laboratory, receipt will be documented on the chain-of-custody form, and the samples will be checked in. The samples will remain under chain of custody throughout the analysis period to ensure that their integrity is preserved. Details are provided below.

27.5 Sample Custody

Chain-of-custody protocols will be used throughout sample handling to establish the evidentiary integrity of sample containers. These protocols will be used to demonstrate that the samples were handled and transferred in a manner that would eliminate possible tampering. Samples for the laboratory will be packaged and shipped in accordance with Tetra Tech SOP SA-1.8 (Appendix A).

A sample is under custody if:

- The sample is in the physical possession of an authorized person.
- The sample is in view of an authorized person after being in his/her possession.
- The sample is placed in a secure area by an authorized person after being in his/her possession.
- The sample is in a secure area restricted to authorized personnel only.

Custody documentation is designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. Each chain-of-custody form is signed and dated by the recipient of a sample or portion of a sample. The person releasing the sample and the person receiving the sample will each retain a copy of the form each time a sample transfer occurs. Chain-of-custody forms will be completed daily to manage samples and to track samples for shipment.

Integrity of the samples collected will be the responsibility of identified persons from the time the samples are collected until the samples, or their derived data, are incorporated into the final report.

The Tetra Tech FOL is responsible for the care and custody of the samples collected until they are delivered to the laboratory or are entrusted to a commercial courier. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time on the chain-of-custody form. This record documents sample custody transfer from the sampler to the laboratory, often through another person or agency (commercial courier). Upon arrival at the laboratory, internal sample custody procedures will be followed as defined in the laboratory SOP.

27.5.1 Laboratory

Laboratory sample custody procedures (receipt of samples, archiving, and disposal) will be used in accordance with the laboratory's SOP. Coolers are received and checked for proper temperature. A sample cooler receipt form will be filled out to note conditions and any discrepancies. The chain-of-custody form will be compared to the enclosed sample containers for accuracy. Samples will be logged into the laboratory information management system and given a unique login number that can be tracked through processing. The Laboratory PM will notify the Tetra Tech FOL or PM verbally or via email upon receipt of any chain-of-custody form/sample receipt variances for clarification or direction from the FOL or PM. Discrepancies and resolutions will be documented on the sample receiving checklist.

Revision No: 1

Date: January 18, 2019

SAP Worksheet #28: Laboratory QC Samples Table

(UFP-QAPP Manual Section 3.4)

Matrix	Groundwater					
Analytical Group	PFAS					
Analytical	PFAS by LCMSMS					
Method/SOP	compliant with QSM 5.1					
Reference	Table B-15/ ME00213			T		1
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPCs
Instrument Blanks	Immediately following the highest standard analyzed and daily prior to sample analysis. The highest standard analyzed as part of the calibration curve or following the calibration curve. If analyzed following the calibration curve, it is not used to extend out the calibration range. It is used only to document a higher concentration at which carryover still does not occur. If sample concentrations exceed this range and the sample(s) following exceeds this acceptance criteria (>½ LOQ), it must be reanalyzed.	Concentration of each analyte must be ≤ ½ the LOQ. Note: Successful analysis following the highest standard analyzed determines the highest concentration at which carryover does not occur.	If acceptance criteria are not met after the highest calibration standard, calibration must be performed using a lower concentration for the highest standard until acceptance criteria are met. If acceptance criteria are not met after the highest standard that is not included in the calibration, the standard cannot be used to determine the highest concentration in samples at which carryover does not occur. If acceptance criteria are not met after sample analysis, additional instrument blanks must be analyzed until acceptance criteria are met. Additional samples will not be analyzed until acceptance criteria are met. Flagging is only appropriate in cases when the sample cannot be reanalyzed and when there is no more sample left.	Analyst, Supervisor	Accuracy/Bias/ Contamination	Same as Method/SOP QC Acceptance Limits.

Revision No: 1

Matrix	Groundwater					
Analytical Group	PFAS					
Analytical	PFAS by LCMSMS					
Method/SOP	compliant with QSM 5.1					
Reference	Table B-15/ ME00213					
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPCs
Extracted Internal	Every field sample,	Added to sample prior	If recoveries are acceptable for	Analyst, Supervisor	Accuracy/Bias	Same as
Standard Analytes	standard, blank, and QC	to extraction.	QC samples but not field			Method/SOP QC
	sample.		samples, the field samples must			Acceptance Limits.
		For aqueous samples	be reprepared and reanalyzed			
		prepared by serial	(greater dilution may be needed).			
		dilution instead of SPE,				
		added to samples prior	If recoveries are unacceptable for			
		to analysis.	QC samples, correct problem and			
			reanalyze all associated failed			
		Extracted Internal	field samples.			
		Standard Analyte				
		recoveries must be	Apply Q-flag and discuss in the			
		within 50% to150% of	Case Narrative only if reanalysis			
		the true value.	confirms failures in exactly the			
			same manner.			
			Failing analytes will be thoroughly			
			documented in the Case Narrative.			

Matrix	Groundwater					
Analytical Group	PFAS					
Analytical	PFAS by LCMSMS	1				
Method/SOP	compliant with QSM 5.1					
Reference	Table B-15/ ME00213					
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPCs
Injection Internal	Every field sample,	Added to aliquot of	If peak areas are unacceptable,	Analyst, Supervisor	Accuracy/Bias	Same as
Standard Analytes	standard, blank, and QC	sample dilutions, QC	analyze a second aliquot of the			Method/SOP QC
	sample.	samples, and	extract or sample if enough			Acceptance Limits.
	Alta mastiva Indostian	standards just prior to	extract remains. If there is not			
	Alternative Injection	analysis.	enough extract, reanalyze the first			
	Internal Standard Analytes are recommended when	Peak areas must be	aliquot.			
	there is obvious		If second analysis meets			
	chromatographic	the area measured in	acceptance criteria, report the			
	interference.	the ICAL midpoint	second analysis. If it fails, either			
		standard.	analysis may be reported with the			
			appropriate flags.			
		On days when ICAL is				
		not performed, the	Apply Q-flag and discuss in the			
		peak areas must be	Case Narrative.			
		within -50% to +50% of				
		the peak area				
		measured in daily initial CCV.				

Matrix	Groundwater]				
Analytical Group	PFAS	1				
Analytical Method/SOP Reference	PFAS by LCMSMS compliant with QSM 5.1 Table B-15/ ME00213					
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPCs
Method Blank (MB)	One per preparatory batch.	>1/2 LOQ or > 1/10 the amount measured in	Correct problem. If required, reprepare and reanalyze MB and all QC samples and field samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. Results may not be reported without a valid MB. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	Analyst, Supervisor	Accuracy/Bias/ Contamination	Same as Method/SOP QC Acceptance Limits.

Matrix	Groundwater					
Analytical Group	PFAS					
Analytical	PFAS by LCMSMS					
Method/SOP	compliant with QSM 5.1					
Reference	Table B-15/ ME00213			1		
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPCs
Laboratory Control Sample (LCS)	One per preparatory batch. Results may not be reported without a valid LCS.	Blank spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. Use in-house LCS	Correct problem then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. Flagging is only appropriate in cases where the samples cannot	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
MS	One per preparatory batch. Not required for aqueous samples prepared by serial dilution instead of SPE.	analytes at a concentration ≥ LOQ	be reanalyzed. Examine the project-specific requirements. Contact Tetra Tech as to additional measures to be taken. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. For matrix evaluation only. If MS results are outside the limits, the data will be evaluated to determine the source(s) of difference, i.e., matrix effect or		Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	Groundwater	1				
Analytical Group	PFAS	-				
Analytical	PFAS by LCMSMS	-				
Method/SOP	compliant with QSM 5.1					
Reference	Table B-15/ ME00213					
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQIs	MPCs
MSD or Matrix	For MSD: One per	For MSD: Sample	Examine the project-specific	Analyst, Supervisor	Precision/	Same as
Duplicate (MD)	preparatory batch.	spiked with all analytes	requirements. Contact Tetra		Accuracy/Bias	Method/SOP QC
		at a concentration ≥	Tech as to additional measures to			Acceptance Limits.
	The MD is a second aliquot	LOQ and ≤ the mid-	be taken.			
	of the field sample that has	level calibration				
	been prepared by serial	concentration.	The data will be evaluated to			
	dilution.		determine the source of			
		For MSD: Use in-house	difference.			
	For MD: Each aqueous	limits of 70-150%.				
	sample prepared by serial		For the specific analyte(s) in the			
	dilution instead of SPE.	RPD ≤ 30% (between	parent sample, apply J-flag if			
		MS and MSD or	acceptance criteria are not met			
		sample and MD).	and explain in the Case Narrative.			
		For Sample/MD: RPD				
		criteria only apply to				
		analytes whose				
		concentration in the				
		sample is greater than				
		or equal to the LOQ.				

Matrix	Groundwater]				
Analytical Group	PFAS					
Analytical Method/SOP Reference	PFAS by LCMSMS compliant with QSM 5.1 Table B-15/ ME00213					
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQls	MPCs
Post-Spike Sample	Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of " <loq" analyte(s).<="" for="" td=""><td>dilution(s) reported for sample with all analytes that have reported value of "<loq" in="" td="" the<=""><td>When analyte concentrations are calculated as "<loq," 70-130%="" acceptance="" and="" appropriate.<="" are="" at="" be="" consecutively="" criteria="" criteria,="" dilutions="" does="" duplicate,="" flagging="" higher="" is="" meet="" met.="" must="" not="" post-spike="" reanalyzed="" recovery="" sample="" sample,="" spike="" td="" the="" until=""><td>Analyst, Supervisor</td><td>Accuracy/Bias</td><td>Same as Method/SOP QC Acceptance Limits.</td></loq,"></td></loq"></td></loq">	dilution(s) reported for sample with all analytes that have reported value of " <loq" in="" td="" the<=""><td>When analyte concentrations are calculated as "<loq," 70-130%="" acceptance="" and="" appropriate.<="" are="" at="" be="" consecutively="" criteria="" criteria,="" dilutions="" does="" duplicate,="" flagging="" higher="" is="" meet="" met.="" must="" not="" post-spike="" reanalyzed="" recovery="" sample="" sample,="" spike="" td="" the="" until=""><td>Analyst, Supervisor</td><td>Accuracy/Bias</td><td>Same as Method/SOP QC Acceptance Limits.</td></loq,"></td></loq">	When analyte concentrations are calculated as " <loq," 70-130%="" acceptance="" and="" appropriate.<="" are="" at="" be="" consecutively="" criteria="" criteria,="" dilutions="" does="" duplicate,="" flagging="" higher="" is="" meet="" met.="" must="" not="" post-spike="" reanalyzed="" recovery="" sample="" sample,="" spike="" td="" the="" until=""><td>Analyst, Supervisor</td><td>Accuracy/Bias</td><td>Same as Method/SOP QC Acceptance Limits.</td></loq,">	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

SAP Worksheet #29: Project Documents and Records Table

(UFP-QAPP Manual Section 3.5.1)

Document	Where Maintained
Sample Collection Documents and Records Project personnel sign-off record Field logbook (and sampling notes) Field sample forms (e.g., sample log sheets, drilling logs, etc.) Chain-of-custody records Sample shipment air bills Equipment calibration logs Photographs FTMR forms SAP including field sampling SOPs SAP regulatory and personnel review acknowledgements Safe work permit forms APP/SSHP	Sample collection documents and records (may include printed copies and electronic information) will be maintained at the Tetra Tech office located at 661 Andersen Drive, Pittsburgh, Pennsylvania, 15220. Project files will be kept in a secured limited-access area and transmitted to the NAVFAC Regional Data Manager who will subsequently forward the data to the Federal Records Center (FRC) for storage, where the files will remain until 50 years after the last decision document for the facility.
Laboratory Documents and Records in the Form of Analytical Data Packages SAP including laboratory SOPs Sample receipt/log-in, custody, and tracking forms Sample storage and disposal records Sample preparation logs Equipment calibration, maintenance, testing, and inspection logs Sample analysis run logs Reported results for field sample, standards, QC checks, and QC samples Data completeness checklists Telephone logs Extraction/clean-up records Raw data EDDs	Analytical results, documents, and records will be provided by the laboratory in printed and electronic formats. Project files will be kept in a secured limited-access area and transmitted to the NAVFAC Regional Data Manager who will subsequently forward the data to the FRC for storage, where the files will remain until 50 years after the last decision document for the facility. Electronic laboratory results will also be verified, entered, and maintained in a database on a password-protected Structured Query Language (SQL) server. Data qualifiers will be added to the database during data validation. After validation, the validated data files will be uploaded to the Navy's NIRIS data management system. Although available in the Administrative Record file, laboratory reports are typically filed at a separate location and are available upon request.
Other Documents All letter and email correspondence with regulatory agencies, including approvals and comments Telephone logs Field investigation data packages Data validation and Review Reports (included tabulated data summary forms) All versions of project reports	Personnel training records and health and safety certificates will be stored in personnel records and electronically in the Tetra Tech training database in the project file at 661 Andersen Drive, Pittsburgh, Pennsylvania, 15220. Project files will be kept in a secured limited-access area and transmitted to the NAVFAC Regional Data Manager who will subsequently forward the data to the FRC for storage, where the files will remain until 50 years after the last decision document for the facility. Field Audit Checklists are not considered part of the Administrative Record file and will be stored in the Tetra Tech project file at 661 Andersen Drive, Pittsburgh, Pennsylvania, 15220, and electronically in the server library. Analytical Audit Checklists will be retained by the respective accreditation authorities.

Revision No: 1

Date: January 18, 2019

SAP Worksheet #30: Analytical Services Table

(UFP-QAPP Manual Section 3.5.2.3)

Matrix	Analytical Group	Sample Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization ⁽¹⁾	Backup Laboratory/ Organization
Groundwater	PFAS	See Worksheet #18	ME00213	21 Days	Shealy Environmental Services, Inc. 106 Vantage Point Drive West Columbia, SC 29172 Lab PM: Nisreen Saikaly 803-227-2704 nsaikaly@shealylab.com	NA

Revision No: 1

¹ Laboratory meets accreditation requirements to support project needs. See footnotes, Worksheet #31.

SAP Worksheet #31: Planned Project Assessments Table

(UFP-QAPP Manual Section 4.1.1)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing CAs	Person(s) Responsible for Monitoring Effectiveness of CA
Laboratory Systems Audit	Every 2 years	External	DoD ELAP Accrediting Body	DoD ELAP Accrediting Body Auditor	Laboratory QAM or Laboratory PM, Shealy	Laboratory QAM or Laboratory PM, Shealy	Laboratory QAM or Laboratory PM, Shealy

Revision No: 1

Revision Date: January 18, 2019

The selected analytical laboratory (Shealy) has successfully completed the laboratory assessment process required as part of the DoD ELAP and as described in the DoD QSM, Version 5.0, July 2013.

Shealy is also accredited to the requirements of the QSM V 5.1 (January 2017) Table B15 for PFAS by LCMSMS for non-potable water and solid and chemical materials

SAP Worksheet #32: Assessment Findings and Corrective Action Responses

(UFP-QAPP Manual Section 4.1.2)

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Time Frame of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response	Time Frame for Response
Laboratory Systems Audit	Written audit report	Laboratory QAM, Wendy Plessinger, Shealy	Specified by DoD ELAP Accrediting Body	Letter	DoD ELAP Accrediting Body	Specified by DoD ELAP Accrediting Body
Field Supervision	Site log book and sample collection log sheets	Linda Klink, PM, Tetra Tech; TBD, FOL, Tetra Tech	Immediately, when discovered	Entry in site log book, potential retraining	Linda Klink, PM, Tetra Tech; FOL, Tetra Tech	Within 24 hours

Revision No: 1

SAP Worksheet #33: QA Management Reports Table

(UFP QAPP Manual Section 4.2)

Type of Report	Frequency	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Data Validation Report	Per Sample Delivery Group (SDG)	Within 3 weeks after receiving the data from the laboratory	Project Chemist or Data Validator, Tetra Tech	PM, Tetra Tech; project file
Major Analysis Problem Identification (Internal Memorandum)	When persistent analysis problems are detected	Immediately upon detection of problem–on the same day	QAM, Tetra Tech	PM, Tetra Tech; QAM, Tetra Tech; Program Manager, Tetra Tech; project file
Project Monthly Progress Report	Monthly for the duration of the project	Monthly	PM, Tetra Tech	PM, Tetra Tech; QAM, Tetra Tech; Program Manager, Tetra Tech; NAVFAC COR and RPM; project file
Laboratory QA Report	When significant plan deviations result from unanticipated circumstances	Immediately upon detection of problem–on the same day	Laboratory PM, Shealy	PM and project file, Tetra Tech

Revision No: 1

SAP Worksheets #34-36: Data Verification and Validation (Steps I and IIa/IIb) Process Table

(UFP-QAPP Manual Section 5.2.1), (UFP-QAPP Manual Section 5.2.2), (Figure 37 UFP-QAPP Manual), (Table 9 UFP-QAPP Manual)

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb ⁽¹⁾	Internal/ External
Sample Log Sheets, Chain- of-Custody Forms, SAP, and Laboratory Sample Login Documentation	The FOL will verify that samples were correctly identified, chain of custody records are legible, data will be traceable to the corresponding samples, all samples listed in SAP Worksheet #s 12, 18, and 20 were collected from intended locations, and the correct sampling and analytical method/SOPs were assigned to samples listed on the chain-of-custody record. The PM will verify that the sampling plan was implemented and carried out as written, and will ensure that any significant deviations are documented in the project report.	FOL and PM, Tetra Tech	I	Internal
Chain-of-Custody Forms	Verify sample shipment completeness against the chain-of-custody record, verify proper sample preservation/integrity, sign to indicate receipt, note any discrepancies, and correct them as necessary. Notify the Tetra Tech FOL or PM of any deviations from sample shipping requirements such as damaged sample containers, or inappropriate temperature. Note uncorrectable discrepancies in the data package Case Narrative.	Laboratory Sample Custodian	I	External
Chain-of-Custody Forms	Verify that the chain-of-custody form is complete and accurate; and was signed and dated by the sampler relinquishing the samples and by the laboratory receiving the samples. Resolve discrepancies if possible. Alert the Tetra Tech PM verbally or via email if discrepancies are unresolvable.	FOL, Tetra Tech	l/lla	Internal
Analytical Calibration Standards	Verify that standards are traceable and meet contract, method, and procedural requirements, as applicable, and include Certificates of Analysis in the laboratory data package. If discrepancies in traceability are found, bring the discrepancies to the attention of the laboratory PM for correction.	Laboratory analyst, Shealy	lla	Internal
SAP, Analytical SOPs, and Analytical Data Packages	Verify that the correct analytical method/SOPs were applied. Establish that all method QC samples were analyzed and in control as listed in the analytical SOP. If method QC is not in control, the Laboratory PM will contact the Tetra Tech Project Chemist or PM verbally or via e-mail for guidance prior to laboratory data package preparation.	Laboratory PM, Shealy	lla	Internal
Laboratory Analytical Data Package	Verify the analytical data package for completeness and accuracy. The Laboratory QAM will sign the case narrative for each data package.	Laboratory QAM, Shealy	1	Internal
Laboratory Analytical Data Package	Review chain-of-custody records to ensure that the required analytical samples was collected, appropriate sample identifications were used, and correct analytical method were applied to each sample. Verify the analytical data package for completeness and accuracy. Obtain missing data package elements from the laboratory. Document unrecoverable elements, if any, in the data validation report submitted to the Tetra Tech PM and alert the Project Chemist or PM.	Data Validator, Tetra Tech	l/lla	External

Revision No: 1

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb ⁽¹⁾	Internal/ External
EDDs/Analytical Data Packages	Verify 100 percent of EDD results for accuracy and completeness against hard copy data package and chain-of-custody records at the start of validation. If required elements are missing, obtain missing elements form the laboratory before completing the validation. If any element cannot be obtained, document the omission in the data validation report and identify the missing elements to the Tetra Tech Project Chemist or PM as early as possible.	Data Validator, Tetra Tech	l/lla	External
Sample Shipment and Storage Conditions, and Holding Times for Representativeness	Verify that sample shipping and storage conditions satisfy Worksheet #19 requirements. Document deviations from requirements in the DV report and notify the Tetra Tech Project Chemist or PM if deviations from the SAP requirements are serious enough to warrant data rejection. Document findings in the DV report.	Data Validator, Tetra Tech	lla	External
QC Samples/MPC Compliance	Ensure that the scheduled laboratory and field QC samples were submitted for analysis and that the MPCs listed in SAP Worksheet #s 12, 15, 22, 24, and 28 were met for all field samples and QC samples. Document findings in the DV report.	Data Validator, Tetra Tech	lla/llb	External
Field and Laboratory Duplicate Analyses for Precision	Verify field sampling precision by checking RPDs for field duplicate samples. Verify laboratory precision by checking RPDs or percent difference values from calibrations, laboratory duplicates, MS/MSDs, and LCS/LCS duplicates (LCSDs). Ensure compliance with MPC accuracy and precision goals listed in Worksheet #s 12, 24, and 28. Document findings in the DV report.	Data Validator, Tetra Tech	IIb	External
SAP/Laboratory Data Packages/EDDs	Conduct Stage 4 data validation on 100 percent of the definitive laboratory data generated using criteria listed in Worksheets #s 12, 15, 24, and 28 and the DoD QSM 5.1 (2017), DoD General Data Validation Guidelines (February 2018), and logic provided in the National Functional Guidelines (NFG) for Inorganic Superfund (USEPA, 2017a) or Organic Superfund (USEPA, 2017b). If not included in the aforementioned, then the logic outlined in the <i>National Functional Guidelines for Superfund Organic Data Review</i> (USEPA, 2017b) will be used to apply qualifiers to the data. Document findings in the DV report.	Data Validator, Tetra Tech	lla/llb	External

Revision Date: January 18, 2019

041817/P Page 83 of 89 SE0351

¹ IIa=Compliance with methods, procedures, and contracts (see Table 10, page 117, UFP-QAPP manual, V.1, USEPA March 2005). IIb=Comparison with MPCs in the SAP (see Table 11, page 118, UFP-QAPP manual, V.1, USEPA March 2005).

SAP Worksheet #37: Usability Assessment

(UFP-QAPP Manual Section 5.2.3)

Data Usability Assessment

Revision No: 1

Date: January 18, 2019

The usability of the data generated during this project directly affects whether project objectives are achieved. The following characteristics will be evaluated at a minimum, and the results of these evaluations will be included in the project report. The characteristics will be evaluated for multiple concentration levels if the evaluator determines that this is necessary. To the extent required by the type of data being reviewed, the evaluator will consult with other technically competent individuals to render sound technical assessments of these data characteristics.

• Completeness

The Tetra Tech PM will designate an individual who, acting on behalf of the Project Team, will prepare a table to compare planned samples and analyses to actual samples and analyses. If deviations from the scheduled sample collection or analyses are identified, the Tetra Tech PM will determine whether the deviations compromise the ability to meet project objectives. If they do, the Tetra Tech PM will consult with the NAVFAC RPM and other Project Team members, as necessary (determined by the NAVFAC RPM), to develop appropriate CAs. The completeness goal for sampling and data is 100 percent. Completeness for sampling (Cs) will be expressed as the percentage of samples collected divided by the number of samples planned for collection, and analytical completeness (Ca) will be computed as the percentage of valid data points divided by the planned number of data points, as follows:

$$%Cs = \frac{No. of \ Valid \ Samples}{No. of \ Planned \ Samples} x100\%$$

$$\%Ca = \frac{No.\,of\,Valid\,Analytical\,Results}{No.\,of\,Planned\,Analytical\,Results} x 100\%$$

Precision

The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether precision goals for field duplicates and laboratory duplicates were met. This will be accomplished by comparing duplicate results to precision goals identified in Worksheet #s 12 and 28. This will also include a comparison of field and laboratory precision, with the expectation that laboratory duplicate results will be no less precise than field duplicate results. If the goals are not met, or if data have been flagged as estimated (J qualifier), limitations on the use of the data will be described in the project report. RPDs will computed as follows for original and duplicate pairs of results:

$$RPD = \frac{200 * |Result_A - Result_B|}{(Result_A + Result_B)}$$

Accuracy

The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether the accuracy and bias goals were met for project data. This will be accomplished by comparing percent recoveries (%Rs) of LCS, LCSD, MS, MSD, and surrogate compounds to accuracy goals identified in Worksheet #28. This assessment will include an evaluation of field and laboratory contamination; instrument calibration variability; and analyte recoveries for surrogates, MSs, and LCSs. If the goals are not met, limitations on the use of the data will be described in the project report. Bias of the qualified results and a description of the impact of identified non-compliances on a specific data package or on the overall project data will also be described in the project report. Accuracy will be computed as follows for MS/MSD samples:

$$%R = \frac{Amount in Spiked Sample - Amount in Sample}{Known Amount Added} X 100 %$$

Date: January 18, 2019

The %R calculation for LCSs and surrogate spikes will be as follows:

$$\%R = \frac{Experimental\ Concentration}{Certified\ or\ Known\ Concentration}\ x\ 100$$

Representativeness

A Tetra Tech Project Scientist, identified by the Tetra Tech PM and acting on behalf of the Project Team, will determine whether the data are adequately representative of intended populations, both spatially and temporally. This will be accomplished by verifying that samples were collected and processed for analysis in accordance with the SAP, by reviewing spatial and temporal data variations (as applicable), and by comparing these characteristics to expectations, including adherence to factors that affect sample integrity such as holding times, preservation, and storage conditions. The usability report will describe the representativeness of the data for each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the Project Scientist indicates that a quantitative analysis is required.

• Comparability

The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether the data generated under this project are expected to be sufficiently comparable to future site data with consideration of the potential for collecting samples and under different site conditions. This will not require quantitative comparisons. If potential comparability deficiencies are identified, potential limitations on data use will be described in the project report.

Sensitivity

The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether project sensitivity goals listed in Worksheet #15 were achieved. If sensitivity goals are not achieved, the limitations on the data will be described in the project report.

Project Assumptions and Data Outliers

The Tetra Tech PM and designated Project Team members will evaluate whether project assumptions are valid. This will typically be a qualitative evaluation but may be supported by quantitative evaluations. The type of evaluation depends on the assumption being tested. Potential data outliers will be excluded from data analyses if a review of the associated data indicates that the results have an assignable cause that renders them inconsistent with the remainder of the data. During this evaluation, the team will consider whether outliers could be indications of unanticipated site conditions.

Describe the evaluative procedures used to assess overall measurement error associated with the project:

Revision No: 1

Date: January 18, 2019

After the completion of data validation, the data and data quality will be reviewed to determine whether sufficient data of acceptable quality are available for decision making. In addition to the evaluations described above, a series of inspections and statistical analyses will be performed to estimate these DQI characteristics. The statistical evaluations will include simple summary statistics for target analytes, such as maximum concentration, minimum concentration, number of samples with non-detected results, number of samples with detected results, and the proportion of samples with detected and non-detected results. The Project Team members, identified by the Tetra Tech PM, will assess whether the data collectively support the attainment of project objectives. The Project Team will consider whether any missing or "X"-flagged data have compromised the ability to make decisions or to make decisions with the desired level of confidence. "X"-flagged data will be qualified with an "R" if rejected. The data will be evaluated to determine whether missing or rejected data can be compensated for by other data.

Duplicate results (original and duplicate) will not be averaged for the purpose of representing ranges of concentrations.

Identify the personnel responsible for performing the usability assessment:

The Tetra Tech PM, Project Chemist, FOL, and Project Scientist will be responsible for conducting the listed data usability assessment. The data usability assessment will be reviewed with the NAVFAC RPM and DHEC. If deficiencies affecting the attainment of project objectives are identified, the review will take place either in a face-to-face meeting or teleconference, depending on the extent of identified deficiencies. If no significant deficiencies are identified, the data usability assessment will simply be documented in the project report and reviewed during the normal document review cycle.

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

The data will be presented in tabular format, including data qualifications such as estimation (J, UJ), serious deficiency (X), or rejection (R). Written documentation will support the non-compliance estimated or rejected data results. The project report will identify and describe the data usability limitations and suggest resampling or other CAs, if necessary. Potential data anomalies will be investigated to determine whether they represent unanticipated site conditions or are true outliers and warrant further investigation, and findings will be included in the project report.

REFERENCES

Revision No: 1

Date: January 18, 2019

CH2M-Jones, 2001a. Environmental Baseline Survey Transfer Phase II Parcels: Volume 1, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. July.

CH2M-Jones, 2001b. Environmental Baseline Survey Transfer Phase II Parcels: Volume 2, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. July.

CH2M-Jones, 2001c. Environmental Baseline Survey Transfer Phase II Parcels: Volume 3, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. July.

CH2M-Jones, 2002a. Environmental Baseline Survey Transfer Phase III Parcels: Volume 1, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. May.

CH2M-Jones, 2002b. Environmental Baseline Survey Transfer Phase III Parcels: Volume 2, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. May.

CH2M-Jones, 2002c. Environmental Baseline Survey Transfer Phase III Parcels: Volume 3, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. May.

CH2M-Jones, 2003a. Environmental Baseline Survey Transfer Phase IV Parcels: Volume 2, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. Final. June.

CH2M-Jones, 2003b. Environmental Baseline Survey Transfer Phase IV Parcels: Volume 3, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. Final. June.

CH2M-Jones, 2005. Environmental Baseline Survey Transfer Phase IV Parcels: Errata Sheets, Charleston Naval Complex, North Charleston, South Carolina. Submitted to: U.S. Navy Southern Division Naval Facilities Engineering Command. Final. February.

DoD, 2013. Quality Systems Manual for Environmental Laboratories, Version 5.0. July 2013.

DoD, 2017. Quality Systems Manual for Environmental Laboratories, Version 5.1. January 2017.

DoD, 2018. General Data Validation Guidelines, Environmental Data Quality Workgroup, February.

Ensafe, 1995. Final Zone I RFI Work Plan Page Changes. April.

Ensafe, 2000a. Environmental Baseline Survey for Transfer, EDC Phase I Parcels: Volume 1 of 2, Charleston Naval Complex, Charleston, South Carolina. Prepared for: Department of the Navy, Southern Division Naval Facilities Engineering Command. July.

Ensafe, 2000b. Environmental Baseline Survey for Transfer, EDC Phase I Parcels: Volume 2 of 2, Charleston Naval Complex, Charleston, South Carolina. Prepared for: Department of the Navy, Southern Division Naval Facilities Engineering Command. July.

Ensafe, 2000c. Draft Environmental Baseline Survey for Transfer, Chicora Tank Farm, Charleston Naval Complex, Charleston, South Carolina. Prepared for: Department of the Navy, Southern Division Naval Facilities Engineering Command. September.

Revision No: 1

Date: January 18, 2019

Ensafe, 2000d. Final Environmental Baseline Survey for Transfer, Marina Area, Charleston Naval Complex, Charleston, South Carolina. April.

Ensafe/Allen & Hoshall, 1993. Interim Final Resource Conservation and Recovery Act Facility Investigation Work Plan, Charleston Naval Shipyard, Charleston, South Carolina. Prepared for: Department of the Navy, Southern Division, Naval Facilities Engineering Command. October.

Ensafe/Allen & Hoshall, 1996. Final Zones D, F, and G Resource Conservation and Recovery Act Facility Investigation Work Plan, Naval Base Charleston, Charleston, South Carolina. June.

Naval Sea Systems Command (NAVSEA), 2017. Performance Specification, Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate, for Fresh and Sea Water, MIL-PRF-24385F(SH) w/ AMENDMENT 2. September 07.

NAVFAC, 2017. *NAVFAC Environmental Restoration Program Recordkeeping Manual*, February. Downloadable from the internet at: https://navfac.navy.mil/products_and_services/ev/products_and_services/ev/products_

NHDES, 2017. Incorporating PFAS as Contaminants of Concern at Waste Sites in New Hampshire. PFAS Stakeholder Meeting Presentation. April 11, 2017.

https://www.des.nh.gov/organization/commissioner/documents/pfas-20170411-stakeholder-meeting.pdf.

Place, B.J. and J.A. Field, 2012. Identification of Novel Fluorochemicals in Aqueous Film-Forming Foams (AFFF) Used by the US Military. Environ Sci Technol. Volume 46, Issue 13. Pages 7120–7127. July.

Resolution Consultants, 2014. Final Groundwater Monitoring Report, Chicora Tank Farm, Long-Term Monitoring (LTM), Charleston Naval Complex, Charleston, South Carolina. Prepared for: Department of the Navy, Naval Facilities Engineering Command, Southeast, BRAC Program Management Office, SE. April.

Resolution Consultants, 2015. Letter: Monitoring Well Abandonment Request for Twenty Shallow Monitoring Wells Located on Chicora Tank Farm, Charleston Naval Complex, North Charleston, South Carolina. October.

Trevet, 2016. Well Searches Around Bases With Potential Perfluoroalkyl Substance Sites at Various Base Realignment and Closure Installations, Former Charleston Naval Complex, South Carolina. October.

USEPA, 2002. *Guidance for Quality Assurance Project Plans (EPA QA/G-5)*. EPA/240/R-02/009. Office of Environmental Information, Washington, D.C. December.

USEPA, 2005. Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP), Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs (Final Version 1), EPA-505-B-04-900A. March.

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4. EPA/240/B-06/001. Office of Environmental Information, Washington, DC. February. USEPA, 2016a. Fact Sheet, PFOA & PFOS Drinking Water Health Advisories, EPA 800-F-16-003. May 2016a.

USEPA, 2016a. Drinking Water Health Advisory for Perfluorooctanic Acid (PFOA). EPA 822-R-16-05. May 2016a.

USEPA, 2016b. Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS). EPA 822 R 16 004. May 2016b.

Revision No: 1

Date: January 18, 2019

USEPA, 2016c. Fact Sheet, PFOA & PFOS Drinking Water Health Advisories, EPA 800-F-16-003. May 2016c.

USEPA, 2016d. Health Effects Support Document for Perfluorooctanoic Acid (PFOA). EPA 822 R 16 003. May 2016d.

USEPA, 2016e. Health Effects Support Document for Perfluorooctane Sulfonate (PFOS). EPA 822 R 16-002. May 2016e.

USEPA, 2017a. Regional Screening Levels for Chemical Contaminants at Superfund Sites. RSL Table Update. June. http://www.epa.gov/reg3hwmd/risk/human/index.htm

USEPA, 2017b. USEPA *National Functional Guidelines for Organic Superfund Methods Data Review (SOM02.4)*. EPA-540-R-2017-002. January. https://www.epa.gov/clp/contract-laboratory-program-national-guidelines-data-review.



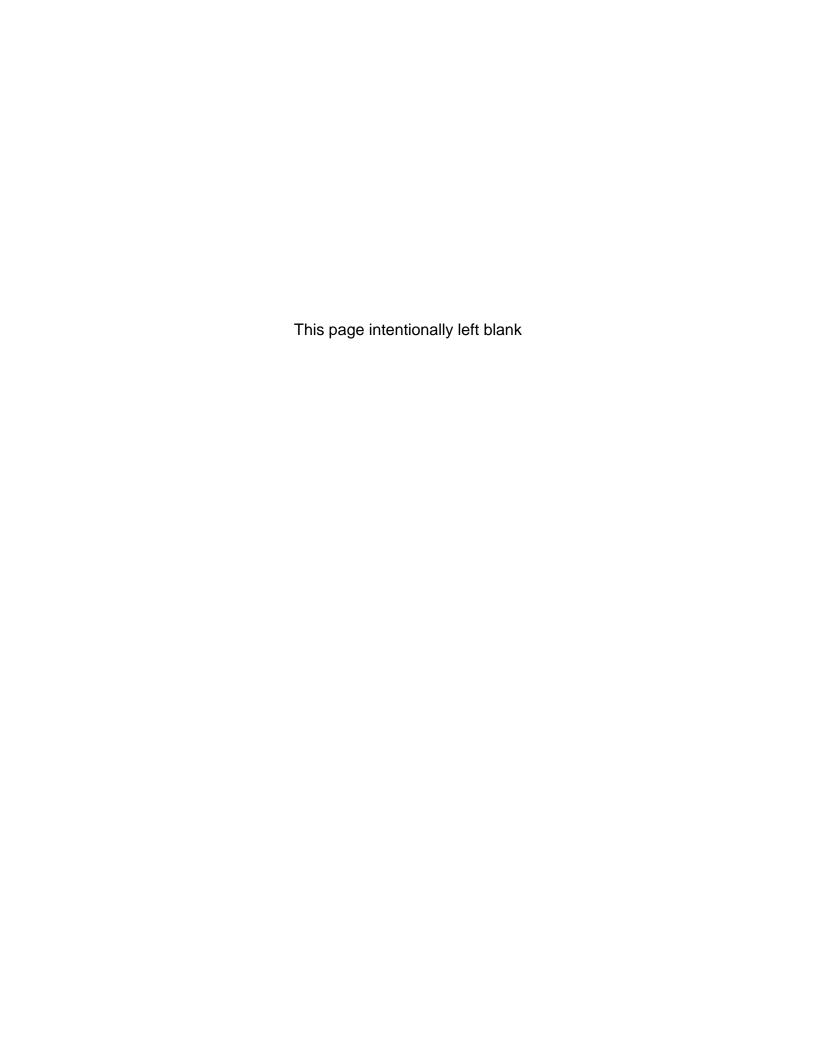


TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 1 of 11

Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
1, 2, 3	SWMU 13 Fire Fighting Training Area Current Owner: U.S. Federal Enclave Zone H	Associated buildings have been demolished, and area is used currently as a parking lot.	Area used by the Fleet and Mine Fire-Fighting Training Center since 1973 for firefighting/suppression training. Approximately 22,000 gallons of diesel fuel/gasoline were used to create controlled fire for firefighting training at Facilities 1302, 1309, and 1310. Located northeast of Building 1815. Site investigated for possible petroleum releases, and results did NOT indicate contamination of soil or shallow groundwater and so was designated No Further Action (NFA). Therefore, the SWMU was not carried forward for further action, and was not included in the Permit as a site needing LUCs.	EBST, EDC Phase III Parcels (CH2M-Jones, H1May 2002)	foam agent use highly suspect based on type of use and time frame of operation, as well as high potential for release to environment. Multiple point sources in area.	f use northeast toward Cooper River.
	Facility 1302, also known as AOC 1302 (within SWMU 13)		Helicopter mockup pad used for fire training purposes; 707 square feet. Located at 2235 South Hobson Avenue between Hobson Avenue to the north and Dyess Avenue to the south. Constructed in 1970. Unoccupied at time of EBST. Facility is a rounded concrete pad surrounded by a concrete curb. A stormwater collection drain located in the center of the sloped circle was connected to the Facility 1308 Oil/Water Separator (OWS) to the northeast of 1302. Surface/stormwater was captured and directed to a stormwater catch basin located approximately 50 feet northwest of the facility, which was then directed to the Facility 1308 OWS.			
1	Facility 1303 (within SWMU 13)		Boat Building/Repair shop, former damage control mockup; 6,237 square feet. Built in 1953.			
	Facility 1309 (within SWMU 13)		Engine mockup used for fire training purposes, 900 square feet. Located at 1938 Dyess Avenue. Dyess Avenue to the south and access road located to the northeast through Hobson Ave. Constructed in 1956. Unoccupied at time of EBST. Facility on a concrete slab with steel support. Runoff drainage flowing toward Facility No. 1308 through an on-site runoff water catch basin.			
	Facility 1310 (within SWMU 13)		Carrier compartment mockup pad used for fire training purposes, 1,218 square feet. Located at 1940 Dyess Avenue. Dyess Avenue to the south and access road located to the northeast through Hobson Avenue. Facility on a concrete slab with steel support. Runoff drainage flowing toward Facility No. 1308 through a runoff water catch basin located approximately 150 feet northwest of Facility 1310. Constructed in 1956. Unoccupied at time of EBST. EBST noted that 25 bags of dry chemical (powder) used as fire retardant were observed outside of the facility.			
	Facility 1308, also known as AOC 1308 (within SWMU 13)		OWS in fire training area. Located at 2235 South Hobson Avenue. Hobson Avenue is located on the northern side, and an access road is located on the eastern side. Facility is an underground concrete containment structure that is 960 square feet (16 feet long by 6 feet wide by 10 feet deep) with inlet and outlet piping and an oil skimmer. The facility was designed to separate and contain/control fuel oil products and other products lighter than water, including runoff from fire training Facilities 1302, 1309 and 1310. The oil and water in the OWS were pumped out for off-site disposal by Public Works in the past. A concrete pad adjacent to the OWS was used as a wash rack. Constructed in 1958. At time of EBST, noted that it is used as a			
			Constructed in 1958. At time of EBST, noted that it is used as a collection sump for the sanitary sewer and does not contain POL products and so no longer used as designed.			

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 2 of 11

Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
, 2, 3 continued)	(within SWMU 13)	Building demolished, and area is currently used as a parking lot.		EBST, EDC Phase III Parcels (CH2M-Jones, May 2002)	and time frame of operation, as well as high potential	Addressed by monitoring wells H659GW009R and H017GW006 selected for sampling for other nearby downgradient facilities (1302, 1308, 1309, and 1310) associated with SWMU 13.
	Facility FBM-61 and SWMU 17 Oil Spill Area Current Owner: U.S Federal Enclave Zone H (both of the monitoring well locations has the same Owner and one of the two monitoring well locations H017GW006 is in the same Zone H; the other monitoring well location, IG11GW005 is in Zone I.)	Facility FBM-61 still exists.	Owner: FLETC	EBST, EDC Phase IV Parcels (CH2M-Jones, February 2005) Interim Final RFI Work Plan (Ensafe, October 1993) SWMU 17 and FBM-61 must both be inspected for LUCs	MEDIUM TO LOW, SWMU 17: No. 5 fuel oil spill that may have been covered with AFFF as a safety precaution. Otherwise, no hazardous or POL wastes were generated by this facility. MEDIUM TO LOW, FBM-61: small quantities. No hazardous or POL wastes generated from this facility. Heating oil spill (18,000 gallons) not expected	In same general area as SWMU 13. Addressed by monitoring wells H017GW006 and IG11GW005 .
	Facility 1891 Current Owner: U.S. Federal Enclave Zone H (both of the monitoring well locations has the same Owner and one of the two monitoring well locations H017GW006 is in the same Zone H; the other monitoring well location, IG11GW005 is in Zone I.)	Demolished.	Covered Storage (Mobile Technical Unit [MOTU] 10); 3,200 square feet. Was large storage/maintenance area called BEQ Maintenance. Built in 1959. Near Facilities 1816 and 1817 of SWMU 178 Transformer Fire. Located on Figure 10-1 as X33A (see more detailed description in Well Grouping 4 below).	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002, Phase 3 V3)	MEDIUM TO LOW: Hydraulic fluids of potential concern. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	
	Facility 1715 Current Owner: U.S. Federal Enclave Zone H	Building status uncertain.	GS Tech Maintenance Shop (Refrigerant Equipment Building); 1,240 square feet. Built in 1968.	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002)	MEDIUM TO LOW: Hydraulic fluids of potential concern. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	In same general area as SWMU 13. Addressed by monitoring well H659GW009R selected for sampling for other nearby downgradient facilities (1302, 1308, 1309, and 1310) associated with SWMU 13.

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 3 of 11

Site Well	Site or Facility	Building Status	Description and Use History	Document References	Potential for PFAS	Anticipated Groundwater Flow Direction and Proposed
Grouping	Current Owner/Zone	Building Status	Description and Use history	Document References	(ranked by level of concern)	PFAS Existing Well Sampling Location
4	Fire Fighting School 2-V (and associated AOC 678 Fire Training Area and AOC 679 washrack) Current Owner: U.S. Coast Guard Zone I X-33A (and associated SWMU 178 Transformer Fire) and adjacent Facility NS-53 Current Owner: U.S. Coast Guard		The Fire Fighting School was former Building 2-V located on the northeastern side of Facility NS-1. Years of operation 1947 to circa 1955. AOC 678 was the fire training area, and AOC 679 was a washrack that was part of the fire training washdown area and was located on the northeastern side of NS-1. The CMS was completed and contamination in the soil and shallow groundwater did NOT exceed action levels and so the site was designated as NFA. Facility No. NS-1, located at 2206 South Hobson Avenue, is a two-story brick structure constructed in 1959 as an administrative building; 46,410 square feet.	V3) Final Zone I RFI Work Plan Page Changes (Ensafe, 1995)	uncertain. The school was reportedly constructed in 1947 and demolished circa 1955, which would be before PFAS were manufactured, however, unknown if fire training operations extended beyond 1955.	In same general area as SWMU 13. Groundwater generally flows to the east toward Cooper River. Sample existing monitoring well I680GW004 . This location is fairly well positioned to capture any contamination present from the Fire Fighting School (2-V), AOC 678, and AOC 679, considering origination from northeastern end of Facility NS-1. Other wells are nearby if well is not present. In addition, this well will provide additional information on X-33A (and associated SWMU 178), and NS-53 that are located in the same general area.
	Zone H Tank 14		X-33A (and associated SWMU 178 Transformer Fire) and adjacent Facility NS-53. Facility X-33A was a former substation constructed in 1943 that		HIGH, X-33A/SWMU 178: Unknown but PFAS	
	Current Owner: U.S. Coast Guard Zone H		housed four transformers, which were removed. The facility was inactive at the time of the EBST inspection. Facility had concrete slab and concrete block walls; 210 square feet. Site originally classified as a SWMU due to the occurrence of a transformer fire southeast of Building 1816. Site soils and groundwater were investigated for PCBs and petroleum compounds. The site was closed as NFA. Location accessed from Hobson Avenue.		contamination via foam agent use suspected during fire emergency response, as well as high potential for release to environment. MEDIUM TO LOW, NS-53: Hydraulic fluids of	
			Buildings 1816 and 1817, both constructed in 1984. Area largely paved. Accessed by Kite Avenue off of West Osprey Street. Also of note, the EBST indicates that the Facility No. 1816 area was an airstrip site at one time (undefined time frame).		potential concern. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	
			NS-53, at time of EBST inspection in 2001, was a Boat Manufacturing Shop (Former Barber Shop/Maintenance Shop); 17,172 square feet. Built in 1959. Historical use as a sea plane hangar and maintenance building (duration unknown); 17,172 square feet. Located at Hobson Avenue and Pirate Street.		HIGH TO MEDIUM, Tank 14: Fire foam suppression system was present based on engineering drawings. Discharges could have impacted soil and groundwater.	
			Tank 14 was a 5,000-barrel tank located west of NS-53 and X-33A. Reference drawing H3900-87 from the map room indicates that a foam system existed that was somewhere near the tank.			
5 (new well location)	SWMU 12 Former Fire Fighter Training Area Current Owner: Charleston County Park and Recreation Commission Zone I	NA. No buildings associated with the SWMU.	SWMU 12 is the former fire fighter training area in the southwestern portion of the southern peninsula of CNC. This unit was a 30- to 50-foot-diameter pit used for training between 1966 and 1971. Oil spill in 1971 overflowed to Shipyard Creek. The pit was closed, filled with ash, and leveled in 1972. Flammable liquids were pumped into the pit, ignited, and then extinguished. NFA was recommended for site soil, and a CMS for shallow groundwater was recommended based on risk.			Groundwater generally flows south to Shipyard Creek. New name ID as I12TEMP1. Nearby monitoring wells have abandoned or are inactive, and there are no wells further downgradient. Therefore, collect a groundwater sample by hand driving a pre-packed screen into the ground on the southern side of the site (Shipyard Creek discharge point lies to the south approximately 50 to 75 feet).
6	Facility 672 Current Owner: U.S. Federal Enclave Zone H	Facility 672 still exists.	Facility 672 was constructed for mock combat training in 1986 and included a vehicle maintenance bay; 8,400 square feet. Building foundation is 4 feet thick. Area was a burning dump as early as 1963 and used in the early 1970s as a waste landfill (SWMU 9), which was capped in 1986 when Facility 672 constructed. Located at 2051 Bainbridge Avenue.		lubricant and other PFAS sources are also of concern, with high potential for release and migration	Groundwater generally flows east/northeast to Cooper River. Sample existing well H009GW011R downgradient of Facility 672 and a portion of SWMU 9. The R suffix in the well name indicates it is a replacement well of H009GW011 shown on Figure 10-1.
			At time of EBST, Facility 672 leased to SANI-TECH as site headquarters and truck maintenance area. Engine oil and lubricant were observed in flammable lockers in vehicle maintenance shed (seven flammable lockers and four storage sheds). Three tanker trucks with water/oil waste pumped from ships were parked outside for off-site disposal.			

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 4 of 11

Vell ing	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
;	Support Building	Both Fire Station Number 1 and Building 245 have been demolished, and area is currently an open field.	Fire Station Number 1: aka Facility 186; 8,680 square feet. Constructed in 1942. Formerly located at near intersection of N Hobson Avenue and Reynolds Avenue. At time of EBST, operating as fire station and noted to be leased by City of North Charleston. Used as a fire station, living quarters, offices, and storage. Fire Station Support Building: aka Facility 245, located adjacent to Fire Station Number 1; 1,200 square feet. Constructed in 1984 for storage including fire extinguishers, bulk storage of fire suppressant chemicals, and firefighting gear. At time of EBST inspection, was storing fire hoses, firefighting gear, and fire extinguishers and was managed and maintained by the North Charleston Fire Dept.	EBST, EDC Phase I Parcels (Ensafe, July 2000)	contamination via foam agent use possible based on type of use and time frame of operation. Of primary concern is Building 245 where fire suppressant chemicals were stored.	Groundwater generally flows to the east/southeast toward Cooper River. Nearby monitoring wells have been abandoned or are inactive. Therefore, sample downgradient existing monitoring well FGELGW012 . Although location is not idea should capture any large plume, if present, and will help determine if this location needs to be sampled in the future closer to the source using a new monitoring well.
	Facility 241 (and associated SWMU 111, 112, 113, and 114 all closed as NFA, and inactive OWS AOC 713). Facility 242 (and associated SWMU 115 closed as NFA, paint booth AOC 614 closed as NFA, and AOC 613 Old Locomotive Repair Shop, and OWSs AOCs 714 and 717)) Also, four 200-gallon ASTs for engine oil and waste oil. Current Owner: City of North Charleston Zone E (the monitoring well location, FGELGW012, has a different Owner/Zone: Commissioner of Public Works Sewer Authority/ Zone E)	Facility 241 and Facility 242 still exist	booth in southwestern corner of facility, 72,000 square feet. Constructed in 1987 as maintenance facility for large cranes. POL products and solvents were stored and used. Operations included	(CH2M-Jones, February 2005) RFI Work Plan Zone D, Zone F and Zone G (Ensafe/Allen and Hoshall, June 1996)	MEDIUM: Multiple sources from large maintenance operations involving hydraulic oils, metal operations, and painting. Very large building. No evidence but spills may have been covered with firefighting foam as a safety precaution. Use of PFAS for misting possible. Numerous POL stains observed on the floor, although they did not extend to outside of the facility. Regardless, high potential for release to environment.	Groundwater anticipated to flow largely to the east/southeas Sample existing monitoring well FGELGW012, which is well placed.
	Facility 1346 (AOC 609 Service Station) Current Owner: Clemson University Zone F	Status unknown.	equipment. SCE&G Fleet Maintenance Facility; 13,910 square feet. Former gasoline station/automotive repair and maintenance shop. Contamination encountered, and free product recovery system was installed in 1995. Waste oil tank was also present, located on southeastern leg of building. Built in 1962.		concern. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	There are no existing monitoring wells nearby the poten source. Sample existing monitoring well FGELGW012 to northeast and F617GW002 to the southeast of Facility 1346 the general direction of groundwater flow; the combination these two wells should provide information if a signification of PFAS is present/absent.

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 5 of 11

Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
9	SWMU 24 Waste Oil Reclamation Facility and Facility 3926 OWS (part of Hobson Fuel Farm) Current Owner: Clemson University Zone F (Monitoring well location H196GW002 different Owner/Zone: U.S. Federal Enclave/Zone H	Demolished.	SWMU 24 is waste oil site from Facility 3901-A (located on Slarrow Street), then transferred to Facility No. 39-A and 39-D, which were ballast/sludge ASTs with capacities of 741,000 gallons each and with asphalt-coated earthen berm containment (out of service at time of EBST inspection in 2002). Tanks were installed in 1964. Used originally for storage, then from 1975 to 1995 used as settling tanks to separate waste oil from ballast water. Facility 3901-B was constructed in 1945 to house a pump used to transfer waste oil to and from Tank 3901-A to treatment tanks 39-A and 39-D. 39-A and 39-D ASTs located on Wood Street, west of intersection with Hobson Avenue. Located in Fuel Farm Area. PNAs in soil are risk drivers. LUC Type: D, U, W Facility 3926 OWS is OWS for ballast/oil treatment facility drained from oil tanks 39-A and 39-D; 13 square feet. Built in 1976. Out of service since base closure in 1995. Located at 1420 Slarrow Street.	Facility 3926: EBST, EDC Phase III Parcels (CH2M-Jones, May 2002)	suspect coupled with high potential for release and	Groundwater generally flows east/southeast to Cooper River. Sample existing downgradient well H196GW002.
13	SWMU 23/AOC 540 Plating Shop WWTS and Former Sludge Pit, Facility 226 (aka Facility 3-A, and SWMU 22 Old Plating Shop Waste Treatment System),and Building 44/SWMU 25 Old Plating Operation), two OWSs, and AST (AST-226-2). Also in area, Building 56 Outside Machine Shop electrical/mechanical group shops to east. Current Owner: CMMC LLC Zone E	Facility 226 and Facility 56 still exists	Facility 226 was constructed in 1976 as a 32,938-square-foot building of three parts, a testing facility, hydraulic shop, and plating shop, converted to a machine shop and large marine equipment valve repair shop for Detyens Shipyard. Facility M-3 to the south of M-3A was a NWS Marine maintenance shop of 902 square feet built in 1941. SWMU 22 Old Plating Shop Waste Treatment System was constructed in 1972 and was replaced in 1982 by the new system, SWMU 23. Prior to 1994, the plating shop was for electroplating (including chrome plating) using dip tanks equipped with wet scrubbers. High levels of chromium and cadmium were encountered at SWMU 22. Wastewater liquids from the dip tanks were collected in the basement and dried in an underground sludge pit located outside of the northeastern corner of the building and identified as SWMU 23. The hydraulic shop stored waste oil in quantities less than 55-gallon drums. Of the two OWSs, one is located at the northwestern corner and the other at the southwestern corner of Building 226. The AST contained 350 gallons of hydraulic oil. Facility 3 is just to the south, and AOC 540 is located in the northern part of the facility. Located at 1181 Truxton Avenue	Parcels (CH2M-Jones, February 2005) NWS Marine maintenance shop: EBST, EDC Phase II Parcels (CH2M-Jones, July 2001) Interim Final RFI Work Plan (Ensafe, October 1993)	contaminants. PFAS may have been used as misting agents during electroplating. Also, hydraulic oils were used. The underground sludge pit is of particular concern.	Groundwater generally flows east/southeast to Cooper River. Sample existing well E065GW008 downgradient of SWMU 23, Facility 226 (3-A), and Facility 56. Sample existing monitoring well E025GW003 , which is well placed for SWMU 25 and will also provide information on Fire Station Number 2/Facility 1079/Facility 1001 described below.
	Fire Station Number 2 Facility 1079 and Facility 1001 Current Owner: Palmetto Railways Zone C (Monitoring well location E025GW003 different Owner/Zone: CMMC LLC/Zone E)	and 1001 still exist. At time of Tetra Tech 2017 site visit, Fire Station Number 2	Fire Station Number 2: Also known as Building 81, located at 2898 Avenue B; 3,000 square feet. Constructed in 1941. Closed in 1996. During a 1999 site visit, it was noted that the building was being used as an evidence room by police. Facility 1001: Cylinder/POL storage; 25,620 square feet. Vacant at time of EBST. Built in 1985. Facility 1079: Hazardous/Flammable Storage Building; 42,370 square feet Vacant at time of EBST. Built in 1985.		Large area. Hydraulic fluids of potential concern.	Groundwater generally flows to the east/southeast toward Cooper River. No existing monitoring wells are nearby for sampling purposes. However, downgradient monitoring well E025GW003, and downgradient well E065GW008 selected primarily for SWMU 23 plating shop, should be sampled. Facilities 1001 and 1079 are further away from the monitoring well but will still provide information on presence/absence of PFAS contamination. The results, in conjunction with weight of evidence from results at other fire stations, will help determine if this location needs to be sampled in the future closer to Fire Station Number 2 using a new monitoring well.

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 6 of 11

Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
10, 11, 12, 13 (continued)	SWMU 87 Less than 90-Day Accumulation Area and SWMU 172 Building 80 Steam Cleaning Operations, AOC 564 OWS and 300-gallon UST, and AOC 576 former indoor oil and paint storehouse Current Owner: CMMC LLC Zone E	Building 80 still exists.	SWMU 172: Former Steam Cleaning Area Building 80. 54,037-square-foot building constructed in 1943 to repair and manufacture ship propellers. Prior to 1995, used as machine shop to repair submarine and turbine motors. Metals in soil and metals and chlorinated VOCs in groundwater are risk drivers. LUC Type: D, E, U, W. AOC 576: OWS (removed) had capacity of 300 to 600 gallons. Site approved for NFA. 1320 Pipefitter Street in the Detyens Shipyard Complex. Also in area are Facility 230 Canteen, previously a fire extinguisher shop, and Facility 1782, a fire extinguisher repair shop.		MEDIUM: Potential for PFAS based on historical use as a large landfill where waste oils and/or firefighting foam-contaminated materials may have been disposed of historically. Also, large maintenance facility with POL used in the machine tooling equipment. Also, fire extinguisher operations occurred in the area.	Groundwater generally flows east/southeast to Cooper River. Sample existing well E172GW001 .
	AOC 666 Current Owner: CMMC LLC Zone E	Facility still present.	AOC 666 is a former UST used to store fuel oil (NS-45), and waste oil UST (NS-44A) from the boilers previously connected to a removed OWS at the time of the EBST located at the southeastern corner of NS-44. BTEX and PAH were detected in groundwater in the area and following natural attenuation, NFA was approved. Nearby NS-44 (AOC 755) was a boiler house constructed in 1958 as a heating plant; 2,600 square feet. Land used as a runway until 1957. Located at 2300 Partridge Avenue.	(CH2M-Jones, May 2002, Phase 3 V3)	concentrations of BTEX and PAH in groundwater (NFA). Nearby fuel oil UST (NS-45) may be the BTEX and PAH source because there was historical staining at the fill port above this tank. Unlikely that PFAS was used associated with runway based on time frame of operations relative to PFAS	Groundwater generally flows southeast to Cooper River. No existing monitoring wells are nearby for sampling purposes. However, sample downgradient monitoring well E172GW001 to provide an indication of presence/absence of PFAS contamination. The results, in conjunction with weight of evidence from results at other petroleum areas, will help determine if this location needs to be sampled in the future closer to the potential source using a new monitoring well.
	AOCs 569, 571, 572, 578, and 723 and Facility No. 25 and 25-A Current Owner: Palmetto Railways Zone E (Monitoring well location E569GW005 different Owner/Zone: CMMC LLC/ Zone E)	All buildings have been demolished.	Former transportation shop and garage (Facility 25, AOC 578), former gasoline station and oil storage area (Facility 30, AOC 569), former paint booth (Facility 177, AOC 571), former motor area (Facility 177, AOC 572), and OWS (AOC 723). Former various shop areas including paint shop and electrical maintenance and paint booth for furniture refinishing. Satellite accumulation area for waste oils and aerosol cans. Facility No. 25 and 25-A was constructed as a U-shaped automobile maintenance facility, and inside the U shape was the auto maintenance yard (Facility 1199). Also, two waste oil USTs were removed. Three drains are located outside, north of the horseshoe opening, and these drains flow into storm drain. Cinder block on concrete slab; 27,453 square feet. Constructed in 1940. Demolished in the 1990s. Located at 1850 Kephart Street.	(CH2M-Jones, February 2005)		Sample existing monitoring well E569GW005 that is downgradient of most of the areas. Also, well E172GW001 should capture any downgradient contamination from AOC 572 and AOC 576 that would not likely be captured by well E569GW005.

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 7 of 11

Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
	Hobson Fuel Farm Current Owner: Commissioner of Public Works Sewer Authority Zone G Facility 1177: Fire Station Number 3 (near Hobson Fuel Farm) Current Owner: Commissioner of Public Works Sewer Authority Zone G (the monitoring well locations ProbeTech well and G633GW001 are both owned by Palmetto Railways/ Zone G)	All tanks have been removed. Per Tetra Tech 2017 site visit, Fire Station Number 3 still exists but is abandoned with broken windows.	Tanks 3900 series at Hobson Fuel Farm: -3900-E Diesel AST 2,350,000 gallons, constructed in 1964. Located on Hobson Avenue between Slarrow Street and Viaduct Road. -3900-F Diesel AST 2,350,000 gallons, constructed in 1964. Out of service since base closure in 1995. Located on the western side of Lamar Avenue near the intersection with Slarrow Street. -3900-H Diesel AST 4,200,000 gallons also known as Facility 3917. 3900-H was a 55,000-gallon tank constructed in 1940 and was demolished in 1986. The subsequent tank at this location was constructed in 1990 and used until 1993. Upon base closure in 1995, the tank was taken out of service. Located at Lamar and Lomberg Avenues. -3900-I Diesel Oil Pumphouse/Lab. -3900-G Diesel AST 4,200,000 gallons also known as Facility 3916. Facility 3900-G was a 55,000-gallon tank constructed in 1940, taken out of service in 1975, and demolished in 1986. The subsequent tank at this location 3916 was constructed in 1990 and taken out of service in 1995 upon base closure. Located at Viaduct Road and South Hobson Avenue. Fire Station Number 3: Also known as Facility 1177. Constructed in 1942. Located at 1365 Viaduct Road. There was a field between Facility 1177 and Building No. 1804 directly south of the fire station.		HIGH TO MEDIUM: Fire foam suppression systems were present based on engineering drawings. Discharges could have impacted soil and groundwater. MEDIUM, Fire Station Number 3: Unconfirmed but PFAS contamination via foam agent use possible based on type of use and time frame of operation. Unconfirmed but the presence of an open field nearby suggests the possibility of training exercises or disposal.	Groundwater generally flows east/southeast to Cooper River. Sample existing wells ProbeTech well and G633GW001. These locations are well positioned to capture any contamination present from both Facility 1177 and Hobson Fuel Farm.
16, 21	AOC 733 Chicora Tank Farm Current Owner: City of North Charleston Chicora Tank Farm Zone G	All tanks have been removed.	Chicora Tank Farm fuel oil and waste oil storage tanks: -3906-K Diesel UST 2,128,000 gallons -3906-L Diesel UST 2,130,000 gallons -3906-M Ship Fuel Oil UST 2,132,000 gallons -3906-N Ship Fuel Oil UST 2,126,000 gallons -3906-O Ballast/Sludge UST 1,153,000 gallons -3906-P Diesel Fuel UST 2,128,000 gallons -3906-Q Boiler Fuel Oil UST 12,000 gallons (AOC 646) -3920 Retention Pond LUC Type: W 23-acre area located between Chicora and Garner Avenues (Highway 52), and Baxter and Clement Avenues.	Groundwater Monitoring Report Chicora Tank Farm LTM (Resolution Consultants, April 2014). Reference drawings from Tetra Tech 2017 visit to map room. All shallow site wells were originally	HIGH TO MEDIUM: Fire foam suppression systems were present based on engineering drawings. Discharges could have impacted soil and groundwater. Also, retention pond of concern as high potential for any release to the environment.	Groundwater generally flows to the east/northeast as per historical documents. Site monitoring wells have largely been abandoned or are inactive. However, five wells were since reinstalled or replaced. Well MW-2R, a Chicora Tank Farm replacement well for MW-2 has been selected for sampling. This well is a shallow well. In addition, sample further downgradient existing well 196GW002. (Monitoring well ProbeTech well for Hobson Fuel Farm and H009GW27D for SWMU 20 will also provide information.) Although the latter three well locations are not ideal, a combination of these three locations plus the source area well MW-2R should capture any large plume, if present.

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 8 of 11

	T	1	T		T	I
Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
17	SWMU 8 Oil Sludge Pit and Facility 161, and AOC 637 Dump Area Current Owner: CNC Redevelopment Zone G	Facility 161 still exists.	SWMU 8 is located on top of SWMU 9 and contains three unlined pits where oil sludge was disposed of between 1944 and 1977; the pits have since been excavated during interim measures, and the area is now a parking lot. Free-floating oil (2 to 4 inches thick) was encountered. LNAPL/PNA/antimony in groundwater and PCBs in soil risk are drivers. LUC Type: D, E, U, W. Located in parking area southwest of Building 161. AOC 637: Dump Area Building 161 Area. Braswell Shipyards Storage (east of Building 672). SVOCs, PCBs, and metals in soil are risk drivers. LUC Type: D, E, U, W.	RFI Work Plan Addendum Zone G (Ensafe, January 2000) RFI Work Plan Zone D, Zone F and Zone G (Ensafe/Allen and Hoshall, June 1996) SWMUs 8 and 9 and Building 161 must be inspected for LUCs	HIGH TO MEDIUM: Disposal of waste oils and lubricant and other PFAS sources suspect coupled with high potential for release and migration of contaminants.	Groundwater generally flows east/northeast to Cooper River. Sample existing well H008GW004 d owngradient of SWMU 8, Facility 161, AOC 637, and a portion of SWMU 9.
Addressed by other wells	SWMU 9 Closed Landfill Current Owners CNC Redevelopment and U.S. Federal Enclave Zones G and H (see well Owners/Zones as previously described)	Landfill closed.	Closed 120-acre landfill closed in the early 1970s with soil cover. SVOCs, PCBs, and metals in soil and VOCs, SVOCs, metals, and dioxins in groundwater are risk drivers. LUC Type: D, E, U, W. Located in open area between Bainbridge and West Road.	SWMUs 8 and 9 and Building 161 must be inspected for LUCs	HIGH TO MEDIUM: Potential for waste disposal of PFAS (waste oils and/or firefighting foam-contaminated materials may have been disposed of) coupled with high potential for release and migration of contaminants.	See SWMU 8, Facility 672, SWMU 13, SWMU 20, and SWMU 196. The wells proposed for sampling in these areas will provide PFAS information on SWMU 9 in the downgradient directions (east, northeast, and southeast).
NA	Fire Station Facility 1656 Current Owner: City of North Charleston Zone A	Facility 135 and Facility 1656 still exist.	Fire Station: Also known as Facility Number 135 located at 2898 Avenue B. Constructed in approximately 1941, originally designed as a gas station then used as a fire station and later as a forklift maintenance ship. This use conflicts with the EBST property summary that indicates Facility 135 was constructed in 1969. The surrounding grounds are paved. At time of EBST, the building was vacant and not in service, and the EBST noted that disposition of reported USTs used to store fuel oil was unknown. Facility 1656: Public works cargo vehicle maintenance garage; 4,000 square feet. Past use as transit cargo handling warehouse. Built in 1992.		HIGH TO MEDIUM, Fire Station: Unconfirmed but PFAS contamination via foam agent use possible based on type of use. Time of operation as fire station unknown. Also, use as a maintenance shop makes waste oils, lubricant, and other PFAS sources suspect. MEDIUM TO LOW, Facility 1656: Hydraulic fluids of potential concern. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	Groundwater generally flows to the southeast toward Cooper River. No sampling planned at this time. No existing monitoring wells are nearby or downgradient for sampling purposes. Weight of evidence from results at other fire stations (Fire Stations 1 and 2) and other maintenance shops will help determine if this location needs to be sampled in the future using a new monitoring well.
18	SWMU 20 Waste Disposal Area Current Owner: U.S. Federal Enclave Zone H	NA	Waste disposal area. Located northeast of Building 903 (former Old Paint Storage Area). SVOCs, PCBs, and metals in soil are risk drivers. LUC Type: D, E, U, W.	Interim Final RFI Work Plan (Ensafe, October 1993) Must be inspected for LUCs.	MEDIUM: Waste disposal of PFAS sources possible coupled with high potential for release and migration of contaminants. However, historical documents note only solid waste and batteries were disposed of (site overlies SWMU 9).	Groundwater generally flows east/southeast to Cooper River. Sample existing well H009GW27D at site.
NA	Facility 236 and OWSs, including AOC 716 Current Owner: CMMC LLC Zone E	Facility 236 still exists	Operations center, Facility 236 pipefitting shop (shop 56), and training center from 1982 to 1996. At time of EBST, used as Detyens Shipyard's corporate offices and machine shop. Operations included Freon distillation, lathe operations, silver brazing, and a hot vapor method for the paint stripping process in the pipe shop. Operations area of the building for all machinery and chemical processes is southern side of building (high bay area). Lubricant oils and oil wastes have been stored and used at the facility. There are two OWSs outside the facility, on the southern and northern sides, and one OWS/collection retention tank inside the building at the northeastern corner. At the time of the EBST, the three OWSs were in place but not in service. One of the OWSs is AOC 716. Constructed in 1982; 145,768 square feet.	(CH2M-Jones, February 2005)	MEDIUM TO LOW: Multiple sources from large maintenance operations involving hydraulic oils, metal operations, and painting. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution. Use of PFAS for misting possible.	No sampling planned at this time. No existing monitoring wells are nearby or downgradient for sampling purposes. Weight of evidence from results at other industrial shops will help determine if this location needs to be sampled in the future using a new monitoring well.

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 9 of 11

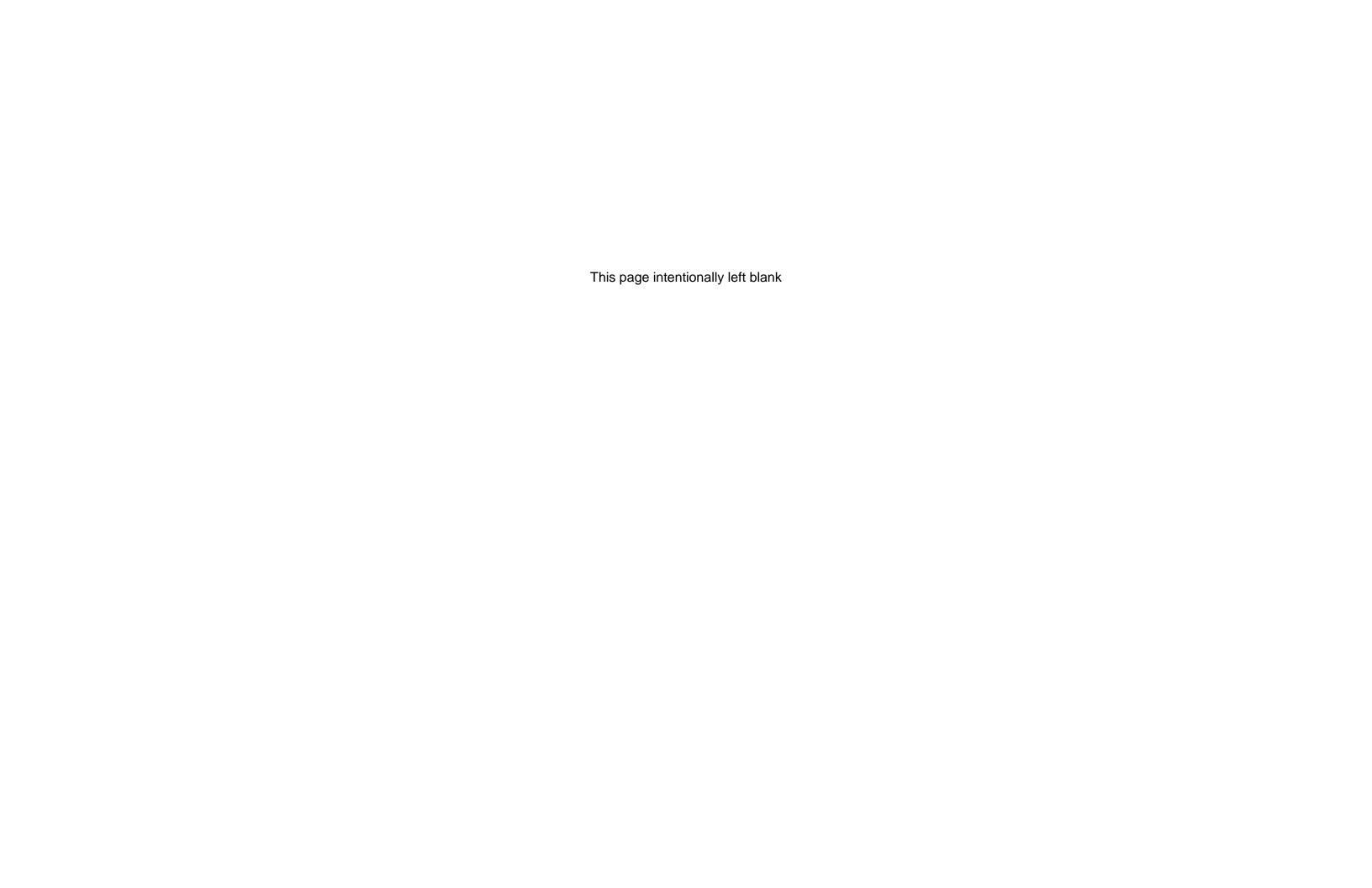
		•				
Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
19	SWMU 18 PCB Spill Area at Facility 1278. Current Owner: CNC Redevelopment Zone E	Facility 1278 still exists.	SWMU 18: Two PCB spills have occurred at Building 1278, both in 1987, first when approximately 75 gallons of Pyranol from a transformer was released to ground during truck loading, and second when a transformer seal cracked spilling 2 to 6 gallons of dielectric fluid containing PCBs. Facility 1278 is currently Battery Processing Slab and Building. Located west of Least Tern Lane.	Interim Final RFI Work Plan (Ensafe, October 1993)	foams used to address spill.	Groundwater generally flows east/southeast. Sample downgradient monitoring well E605GW007 .
	Facility 69 and 69A Warehouse, and AOCs 616 Paint Shop and AOC 617 Galvanizing Shop Facility 1824 and AOC 619 former oil storage yard Current Owner: Clemson University Zone E (Note that well located in area, E605GW007, is in same Zone E but has a different Owner: CNC Redevelopment)	Facility 1824 still exists.	Facility 69 and 69A: Warehouse with minor maintenance and repairs for forklifts; 82,533 square feet. Year of construction 1942. Formerly had paint shop (former Facility 1202) and galvanizing plant (former facility 1176). Hydraulic oil stain observed during inspection. 1145 Pierside Street west of Dry Docks 3 and 4 Facility 1824: Constructed in 1990 as hazardous/flammable storage facility including storage of plating solutions and petroleum products; 17,412 square feet. Concrete floor, each of nine rooms had its own containment trench drains. Since 1995 used as a 90-day permitted hazardous waste accumulation area. Facility lies within AOC 619, a former oil storage yard used to store waste oil, possibly in an open pit, that was approved for NFA.		paint shop, galvanizing, oil storage. Of note, although hydraulic oil stain observed during inspection, stains did not extend off of the concrete or to a floor drain.	Groundwater generally flows east/southeast. No existing monitoring wells are nearby for sampling purposes. Sample downgradient monitoring well E605GW007 to provide an indication of presence/absence of PFAS contamination. The results, in conjunction with weight of evidence from results at other industrial areas, will help determine if this location needs to be sampled in the future closer to the potential source using a new monitoring well.
NA	SWMU 166 Automobile Service Rack Area Current Owner: City of North Charleston/Berkeley Charleston Dorchester COG Naval Annex Zone K	Demolished.	Former automobile service shop. Location of Former Oil Spill and PCB Release. North of Building 22, which is a paint shop. Basewide Naval Annex. Chlorinated solvents in groundwater are risk drivers. LUC Type: U, W	Must be inspected for LUCs.	concern. Oil spill area. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution	No sampling planned at this time. No existing shallow monitoring wells are nearby or downgradient for sampling purposes. Weight of evidence from results at other spill areas will help determine if this location needs to be sampled in the future using a new monitoring well.
NA	Facilities 3911 and 3912 Facility 3914 Current Owner: CNC Redevelopment Zone G	Demolished.	Facility 3911 and 3912: Lubricant Storage Tanks. Used for storage of 9250 lubrication oil. 50,000 gallons each. Built in 1977 and used until base closure in 1995. Most of asphalt berm was eroded away by the time of 2001 survey. Located at 1135 Pierside Street. Facility 3914: Former POL Operation/Sampling/Testing Building; 140 square feet. Built in 1991 and used until 1995 to house computers controlling fuel transfer pumps. Located at 1131 Pierside Street.	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002, Phase 3 V3)	precaution.	No sampling planned at this time. No existing monitoring wells are nearby or downgradient for sampling purposes. Weight of evidence from results at other POL areas will help determine if this location needs to be sampled in the future using a new monitoring well.
	Facility 1501 Facility 1509 Current Owner: FLSC Properties LLC Zone D	Facility 1501 still exists. Facility 1509 is demolished. Demolished.	Facility 1501; Truck fleet maintenance center; 11,280 square feet. Past use as warehouse. Built in 1964. Facility 1509; Maintenance repair and storage; 12,444 square feet. Past use as storage. Built in 1963.	EBST, EDC Phase I Parcels (Ensafe, July 2000)	concern. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	Groundwater generally flows south/southeast to Cooper River. There are no existing monitoring wells nearby the potential source. Sample existing monitoring well E569GW005 to the northeast of Facility 1501 and 1509 in the general direction of groundwater flow, which should provide information if a significant source of PFAS is present/absent. The results, in conjunction with weight of evidence from results at other maintenance areas, will help determine if this location needs to be sampled in the future closer to the potential source, using a new monitoring well.
	Facility 220 Current Owner: City of North Charleston Zone B	Demolished.	Golf cart maintenance garage; 2,800 square feet (site visit identified as golf pro shop and snack bar). Built in 1968. Hydraulic fluids and lubricating oils were associated with the building.	EBST, EDC Phase I Parcels (Ensafe, July 2000)		No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas.

TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 10 of 11

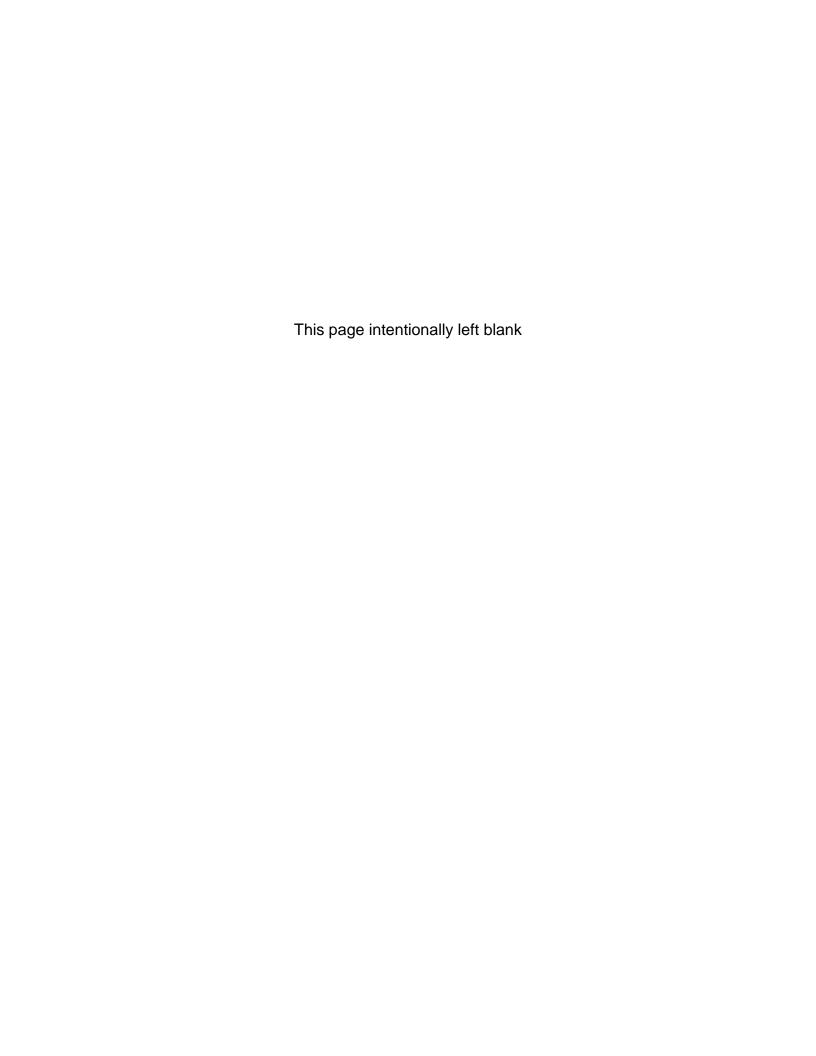
Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
NA	Facility X-10, X-11, X-12 (and AOC 720 OWS), and 1831 Current Owner: CNC Redevelopment Zone G		Facility X-10: Originally constructed to store submarine materials (southern end) and MWR vehicle maintenance (northern end). Since base closure, used as a storage warehouse for used office furniture. Constructed in 1943; 24,735 square feet. Located at 2275 South Hobson Avenue, near the berthing Pier N complex. Facility X-11: Former Public Works Maintenance Shop (demolished); 4,129 square feet. Built in 1944. Demolished after base closure. Located at 2279 South Hobson Avenue. Facility X-12: Former Maintenance Shop (demolished); 1,500 square feet. Built in 1959. Demolished after base closure, building foundation remains. Associated with AOC 720, an inactive OWS associated with an inactive wash rack. The OWS was covered with soil. Located at 2277 South Hobson Avenue, north of Halsey Street. Facility 1831: Former Hazardous/Flammable Storage; 800 square feet. Unknown date of construction. 2277 South Hobson Street, west of Halsey Street.	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002, Phase 3 V3)	MEDIUM TO LOW: Hydraulic fluids of potential concern from X-10, X-11, and X-12 maintenance areas. Although no evidence was found, spills may have been covered with firefighting foam as a safety precaution. Groundwater contamination was not identified. Although there were oil stains observed on the floors, no evidence of a release to the environment.	No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas.
NA	Facility 46 Former Compressor and Saltwater Pumphouse. Current Owner: CMMC LLC Zone E	Facility still exists.	5,437 square feet. Year construction 1941. Located at 2020 Hayter Street.	EBST, EDC Phase IV Parcels (CH2M-Jones, February 2005)		No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas.
NA	NS-19 Current Owner: U.S. Federal Enclave Zone I	Demolished.	Building includes office, classroom, locker room, and storage area/maintenance area; 3,200 square feet. Located at 1050 Pirate Street. Concrete foundation; constructed in 1959 for MOTU and FTSC training and storage. Inactive at time of EBST.	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002, Phase 3 V3)	LOW: Incidental stains; some appear to be from petroleum products but did not constitute a potential release to the environment. No groundwater contamination nearby.	No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas.
NA	SWMU 196 Building 1838 Current Owner: U.S. Federal Enclave Zone H	Unknown.	Area behind Building 1838, the former public works storage yard. PNAs and arsenic in soil and PNAs in groundwater are risk drivers. LUC Type: D, E, U, W.	SWMU 196 Building 1838 Zone H Must be inspected for LUCs	was present.	SWMU 196/Building 1838 sampling is addressed by monitoring well 196 GW002 selected for sampling for other nearby higher priority PFAS sources. Namely, the well is selected as downgradient of AOC 733 Chicora Tank Farm and selected as the southwest side of SWMU 9 Closed Landfill.
NA	Facility 246 RCRA hazardous waste storage facility and associated AOC 706 (downgradient of SWMU 9) Current Owner: CNC Redevelopment Zone G	Facility still exists.	Constructed in 1986 as a RCRA Part B-permitted 90-day TSD facility and operated until September 1993. Only containerized wastes stored. Concrete foundation; included spill containment. Also used as a sanitary landfill at some point between 1930 and 1973. Located at 2145 Dyess Avenue. Leased to WSI of the Southeast, LLC, in late 2001; hydraulic oil, used oil tank, used oil filters, and synthetic lubricant drums in Gear Shed were present during EBST inspection.	EBST, EDC Phase IV Parcels (CH2M-Jones, February 2005) RFI Work Plan Addendum Zone G (Ensafe, January 2000)	LOW: No record of fires or releases and spill containment was present.	No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas.
NA	Facility 1883 Current Owner: South Carolina State Port Authority Zone H	Demolished	Lawn mower maintenance; 960 square feet. Past use as CBU-412 Storage. Built in 1978.	EBST, EDC Phase I Parcels (Ensafe, July 2000)	no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas. Small facility.
NA	Facility 1226 Current Owner: Palmetto Railways Zone C	Facility 1226 still exists although appears to be damaged.	Former Shop Repair Storage; 341 square feet. Built in 1964.	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002)	no evidence was found, spills may have been covered with firefighting foam as a safety precaution.	No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas. Small facility.

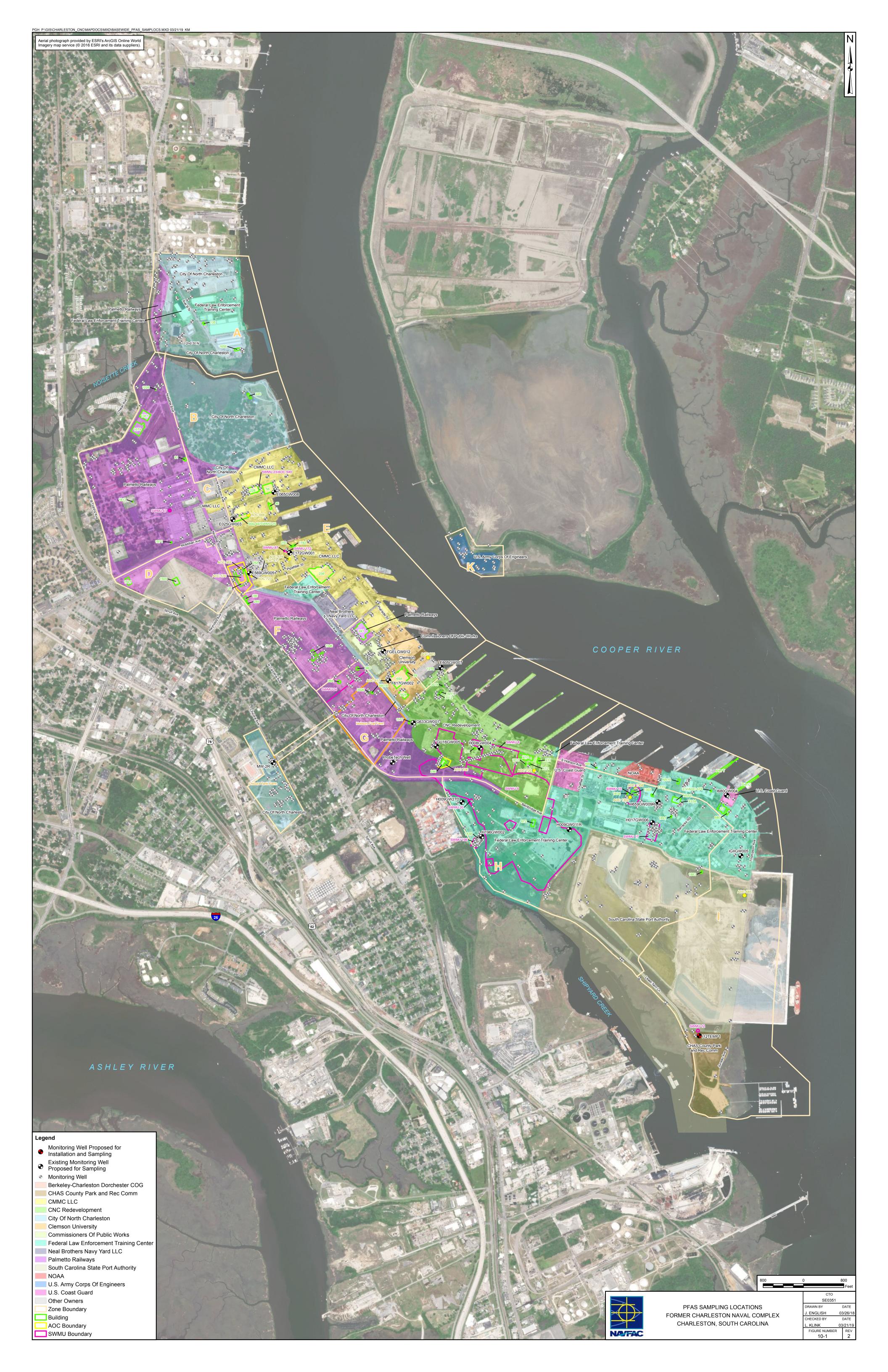
TABLE 10-1 SITE/FACILITY RANKING AND MONITORING WELL LOCATIONS FOR PFAS SAMPLING FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA Page 11 of 11

Site Well Grouping	Site or Facility Current Owner/Zone	Building Status	Description and Use History	Document References	Potential for PFAS (ranked by level of concern)	Anticipated Groundwater Flow Direction and Proposed PFAS Existing Well Sampling Location
	NS-9 Pier NS-10 Pier Current Owner: U.S. Federal Enclave Zone I	Piers still exist but renamed as Pier T and Pier U.	Concrete piers built in 1958. Ships berthed occasionally discharged oil wastewater into parked tanker trucks. NS-10 Pier used for refueling ships. Located at 2130 Thompson Avenue.	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002, Phase 3 V3)	LOW: Salt water for firefighting noted as opposed to foam. Only occasional waste oil operations and no record of spills. Spills likely would have entered Cooper River and been diluted. No staining observed.	
NA	Facility 169 Current Owner: U.S. Federal Enclave Zone I	Facility still exists.	Former Flammable Storehouse; 512 square feet. Built in 1959.	EBST, EDC Phase III Parcels (CH2M-Jones, May 2002)		No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas. Small facility.
	Facility 1571 Current Owner: Palmetto Railways Zone C	Unknown status.	Flammable Storage Shelter; 704 square feet. Built in 1977.	EBST, EDC Phase II Parcels (CH2M-Jones, July 2001)		No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas. Small area.
NA	Facility 1813 Current Owner: Palmetto Railways Zone C	Demolished.	Flammable Storage; 99 square feet. Built in 1984.	EBST, EDC Phase II Parcels (CH2M-Jones, July 2001)		No sampling planned at this time pending results from HIGH TO MEDIUM and MEDIUM PFAS potential source areas. Small area.
NA	SWMU 47 Burning Dump NSC Building 66 Current Owner: Palmetto Railways Zone C	NA	Building 66 located to the west of facility 7. SWMU 47 was a burning dump in the late 1920s for various types of wastes, including medical wastes. Underneath Bldg NSC-66.	EBST, EDC Phase 2 Parcels (CH2MHill, 2001)	LOW: Site operated before PFAS were manufactured.	No sampling planned at this time.
	AOC 603 Burning Dump DryDock #3 Area Current Owner: Clemson University Zone E	NA	AOC 603 was a former burning dump which was used during the 1920s and 1930s, located where Dry Dock 3 currently exists. Little information exists.	RFI Report Addendum, Area of Concern 602 and 604 and SWMU 106/AOC 603 Zone E (CH2M Hill, August 2001)	LOW: Site operated before PFAS were manufactured.	No sampling planned at this time.
NA	AOC 685 Former Smoke Drum Current Owner South Carolina State Port Authority Zone I	NA	AOC 685 is a Former Smoke Drum Site with unknown use, which reportedly operated from 1941 until 1953. Located on the west side of Juneau Avenue, south of Partridge venue.	Final Zone I RFI Work Plan (Ensafe, April 1996) Potential for PFAS:	LOW: Small size and unlikely source of release.	No sampling planned at this time.









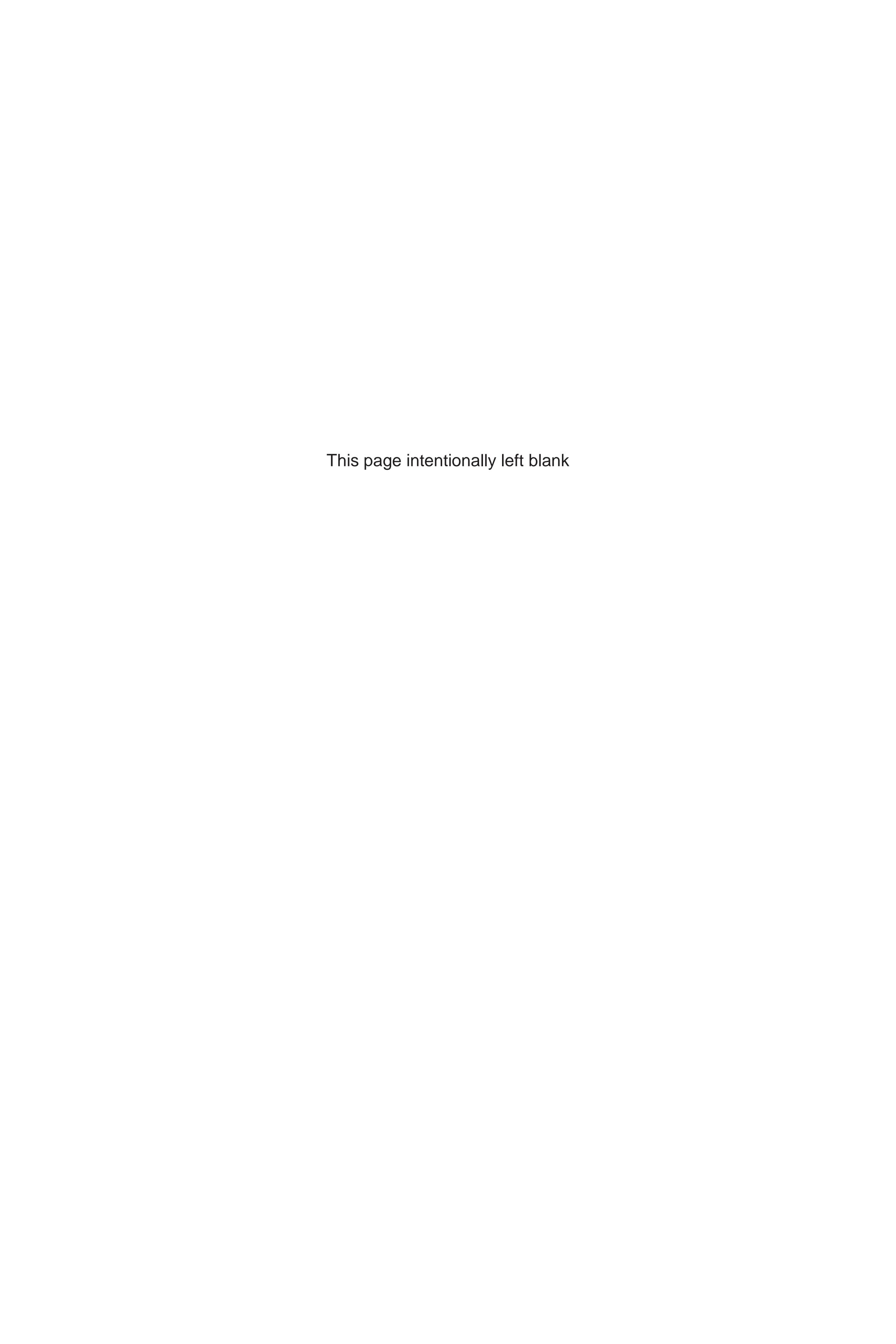
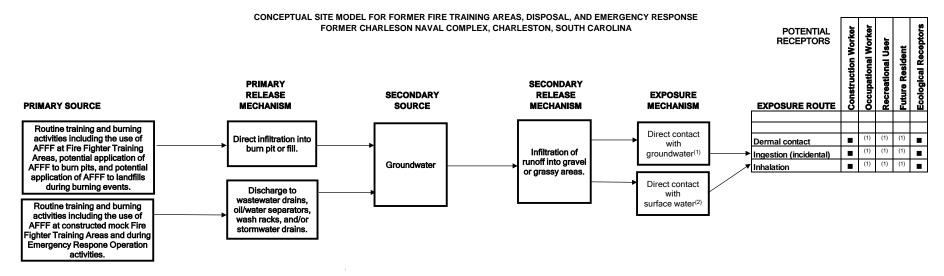


FIGURE 10-2

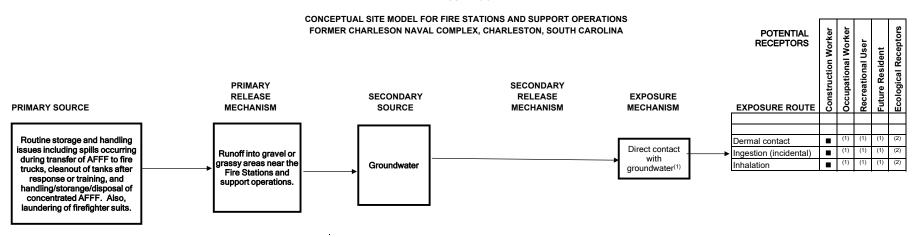


■ = POTENTIALLY COMPLETE EXPOSURE PATHWAY

Footnotes:

- 1 Exposure to groundwater is considered to be a potentially complete pathway only for the construction worker because the groundwater at these sites is not a potable drinking water source. Direct contact for construction workers is considered to be a potentially complete pathway because contact could occur during excavation or construction activities.
- 2 Depending on site proximity to surface water (Cooper River), groundwater could discharge to surface water, allowing direct contact by receptors. The point of groundwater discharge is being used to represent the greatest concentration levels to which ecological receptors could be exposed, and hence represent the greatest potential risk for ecological receptors.

FIGURE 10-3

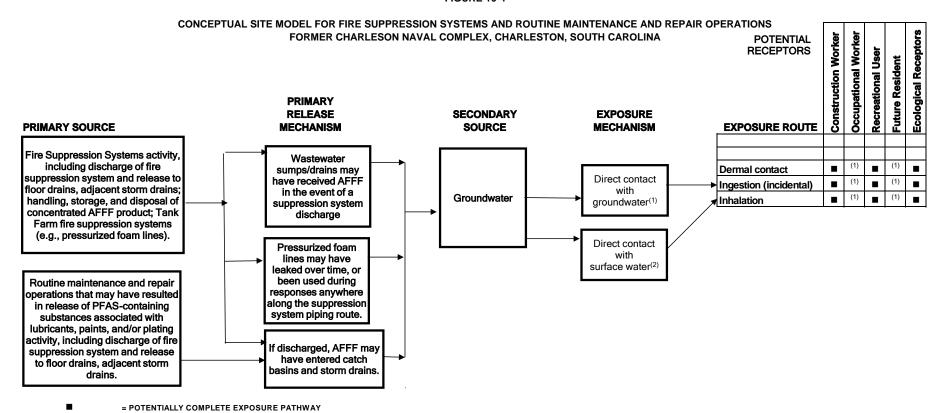


= POTENTIALLY COMPLETE EXPOSURE PATHWAY

Footnotes:

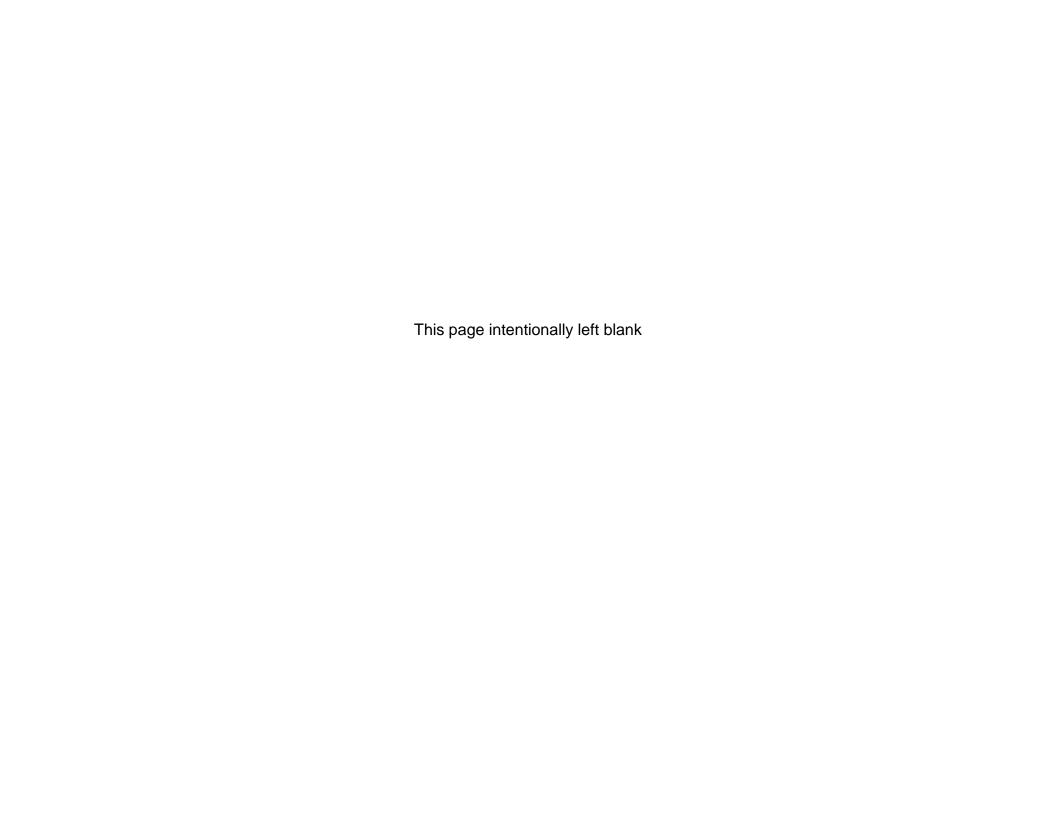
- 1 Exposure to groundwater is considered to be a potentially complete pathway only for the construction worker because the groundwater at these sites is not a potable drinking water source. Direct contact for construction workers is considered to be a potentially complete pathway because contact could occur during excavation or construction activities.
- 2 Direct contact with groundwater is considered to be an incomplete pathway for ecological receptors. Groundwater does not discharge to surface water bodies near the fire station locations at former CNC.

FIGURE 10-4

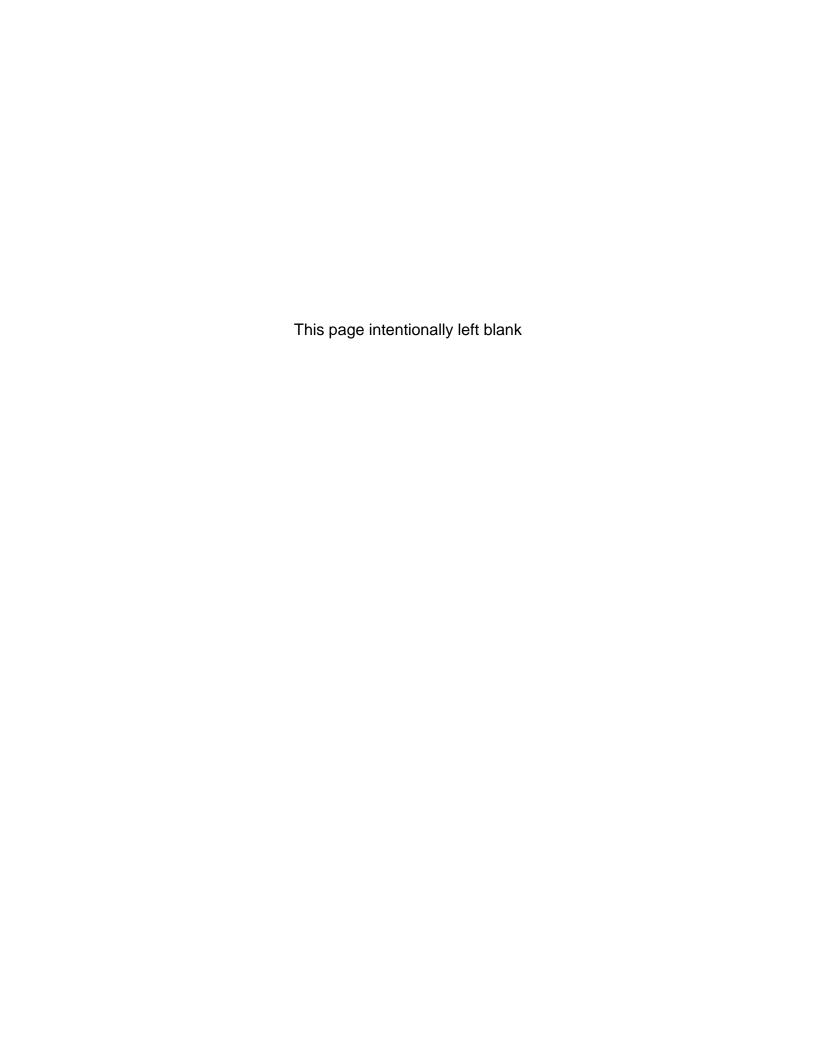


Footnotes:

- 1 Exposure to groundwater is considered to be a potentially complete pathway only for the construction worker because the groundwater at these sites is not a potable drinking water source. Direct contact for construction workers is considered to be a potentially complete pathway because contact could occur during excavation or construction activities.
- 2 Depending on site proximity to surface water (Shipyard Creek and Cooper River), groundwater could discharge to surface water, allowing direct contact by both human and ecological receptors. The point of groundwater discharge is being used to represent the greatest concentration levels to which offshore receptors could be exposed, and hence represent the greatest potential risk for offshore receptors.



APPENDIX A FIELD STANDARD OPERATING PROCEDURES



Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Sample and Evidence Management			
Effective Date: January 29, 2013	Number: SESDPROC-005-R2		
Aut	hors		
Name: Art Masters			
Title: Environmental Scientist, Regional Expe	rt		
Signature: Le M D	ate: 1/23/13		
Approvals			
Name: Danny France			
Title: Chief Enforcement and Investigations E	Branch		
W/WWW//	ate: 1/23/13		
Name: John Deatrick			
Title: Chief, Ecological Assessment Branch			
Signature: The Deathth D	ate: 1/23/13		
Name: Bobby Lewis			
Title: Field Quality Manager, Science and Ecosystem Support Division			
Signature: D	ate: 1/23/13		

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-005-R2, Sample and Evidence Management, replaces SESDPROC-005-R1	January 29, 2013
General: Corrected any typographical, grammatical, and/or editorial errors.	
General: Replaced all references to FORMS with the generic term sample custody software program. The specific sections are listed below: Section 3.3 Section 3.4 Section 4.2 Section 5	
Title Page: Changed the EIB Branch Chief from Antonio Quinones to Danny France. Changed the EAB Branch Chief from Bill Cosgrove to John Deatrick (Acting). Changed the Field Quality Manager from Laura Ackerman to Bobby Lewis.	
Revision History: In the last sentence, changed Field Quality Manager to Document Control Coordinator.	
Section 1.2: Added the following statement - Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.	
Section 1.3: Changed requirement so that the DCC is responsible for ensuring the most recent version of the procedure is placed on the SESD LAN and for maintaining records of review conducted prior to its issuance. Deleted reference to the H: drive.	
Section 2.2 Changed requirement for comments on sample label to make comments optional.	
Section 2.2.2 Removed requirement for printed copies of photographs in the official file.	
Section 3.3 Removed different custody requirements for criminal investigations so that all projects are treated consistently.	
Section 3.4 Removed statement in the fourth paragraph regarding retention of paper air bills in the official project file to reduce unnecessary paperwork. The air bill number or shipment tracking number is recorded on the chain of custody.	

SESDPROC-005-R1, Sample and Evidence Management, replaces SESDPROC-005-R0	November 1, 2007
General Updated referenced procedures to reflect most recent version.	
Replaced "shall" with "will".	
Cover Page: Changed title for Antonio Quinones from Environmental Investigation Branch to Enforcement and Investigations Branch. Changed Bill Cosgrove's title from Acting Chief to Chief.	
Section 1.3 Updated information to reflect that procedure is located on the H: drive of the LAN.	
Section 1.4 Added reference for the SESD Operating Procedure for Control of Records. Alphabetized and revised the referencing style for consistency.	
Section 2.2.3 Added that Confidential Business Information will be handled in accordance with SESD Operating Procedure for Control of Records.	
SESDPROC-005-R0, Sample and Evidence Management, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	Ge	neral Information	5
	1.1	Purpose	
	1.2	Scope/Application	
	1.3	Documentation/Verification	
	1.4	References	
2	Sar	mple and Evidence Identification	
	2.1	Introduction	
	2.2	Sample and Evidence Identification Procedures	7
	2.2	=	
		.2 Photograph, Digital Still Image and Video Identification	
	2.2	.3 Identification of Physical Evidence	
3		ain-of-Custody Procedures	
	3.1	Introduction	
	3.2	Sample Custody	10
	3.3	Documentation of Chain-of-Custody	
	3.4	Transfer of Custody with Shipment	
4	Re	ceipt for Samples Form (CERCLA/RCRA/TSCA)	
	4.1	Introduction	
	4.2	Receipt for Samples Form	
5		mple Custody Management Software	

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed by SESD field investigators when handling and managing samples and other types of evidence after their collection and during delivery to the laboratory.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators when handling and managing samples and other evidence collected to support SESD field investigations. On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, SESDPROC-209, Most Recent Version

USEPA Region 4 Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM), November 2001

USEPA Digital Camera Guidance for EPA Civil Inspections and Investigations, July 2006

2 Sample and Evidence Identification

2.1 Introduction

Sample identification, chain-of-custody records, receipt for sample records and other field records will be legibly recorded with waterproof, non-erasable ink, unless otherwise specified. If errors are made in any of these documents, corrections will be made by crossing a single line through the error and entering the correct information. All corrections must be initialed and dated. If possible, all corrections should be made by the individual making the error.

Following are definitions of terms used in this section:

Field Investigator

Any individual who performs or conducts field sampling, observation and/or measurement activities in support of field investigations

Project Leader

The individual with overall responsibility for conducting a specific field investigation in accordance with this procedure

Field Sample Custodian

Individual responsible for identifying the sample containers and maintaining custody of the samples and the Chain-of-Custody Record

Sample Team Leader

An individual designated by the project leader to be present during and responsible for all activities related to the collection of samples by a specific sampling team

Sampler

The individual responsible for the actual collection of a sample

Transferee

Any individual who receives custody of samples subsequent to release by the field sample custodian

Laboratory Sample Custodian

Individual responsible for accepting custody of samples from the field sample custodian or a transferee

One individual may fulfill more than one of the roles described above.

2.2 **Sample and Evidence Identification Procedures**

2.2.1 Sample Identification

The method of sample identification used depends on the type of sample Field measurement samples are those collected for specific field analysis or measurement where the data are recorded directly in bound field logbooks or on the Chain-of-Custody Record. Examples of field measurements and analyses include XRF, pH, temperature, dissolved oxygen and conductivity. Samples collected for laboratory analysis will be identified by using a stick-on label or a tag which is attached to the sample container. In some cases such as biological samples, the label or tag may have to be affixed to a bag containing the sample. If a sample tag is used, the sample should be placed in a bag, then the sample and the tag will be placed in a second bag.

The following information will be included on the sample label or tag using waterproof, non-erasable ink:

- Project number;
- Field identification or sample station number;
- Date and time of sample collection;
- Designation of the sample as a grab or composite;
- Whether the sample is preserved or unpreserved;
- The general types of analyses to be performed.

Other information such as readily detectable or identifiable odor, color, or known toxic properties may be added as deemed necessary by the project leader or sample custodian.

2.2.2 Photograph, Digital Still Image and Video Identification

Photographs and Digital Still Images

When photographs or digital images are taken for purposes of documenting and supporting a field investigation, a record of each exposure or image will be kept in a bound field logbook. The following information will be recorded in the logbook:

An accurate description of what the photograph or image shows, including orientation, if appropriate;

- The date and time that the photograph or image was taken;
- The name of the individual who took the photograph or digital image.

When photographs are taken with a film camera, the film should be developed with the negatives supplied uncut, if possible. The identifying information that was recorded in the field logbook will be entered on the back of the prints.

When digital images are obtained during a field investigation, an electronic copy of the unaltered investigation-related images will be placed in the official files. If deemed necessary due to project requirements, a printed copy of the original photographs may be placed in the official file. For enforcement cases, it is imperative that the individual who took the image be identified in the field logbook in the event their testimony is required.

Video

When a video recording is used as evidence in an enforcement case, the following information should be recorded in a bound field logbook:

- The date and time that the video was recorded;
- A brief description of the subject of the video;
- The person recording the video.

An audio record may also be included in the video tape with the above logistical information, as well as a narrated description of the video record.

A label will be placed on the video media with the appropriate identifying information (i.e., project name, project number, date, location etc.). In the event testimony regarding a video recording is required for an enforcement case, one individual should be responsible for recording the video for each case. The original, unaltered recording will be placed in the official files.

2.2.3 Identification of Physical Evidence

Physical evidence, other than samples, will be identified, when possible, by recording the necessary information on the evidence. When samples are collected from vessels or containers which can be moved (drums for example), the vessel or container should be marked with the field identification or sample station number for future identification. The vessel or container may be labeled with an indelible marker (e.g., paint stick or spray paint). The vessel or container need not be marked if it already has a unique marking; however, these markings will be

recorded in the bound field logbooks. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain copies of recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. A unique identifier will be recorded on the document with that information as well as the following recorded in the logbook:

- Starting and ending time(s) and date(s) for the chart;
- An instantaneous measurement of the media being measured by the recorder will be taken and entered at the appropriate location on the chart along with the date and time of the measurement; and
- A description of the location being monitored and other information required to interpret the data such as type of flow device, chart units, factors, etc.

The field investigator will indicate who the chart (or copy of the chart) was received from and enter the date and time, as well as the field investigator's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field investigator's signature, the date, the number of pages and from whom they were received. Documents that are claimed by a facility to be "confidential" and, therefore, potentially subject to the Confidential Business Information requirements, will be handled in accordance with SESD Operating Procedure for Control of Records (SESDPROC-002).

3 Chain-of-Custody Procedures

3.1 Introduction

Chain-of-custody procedures are comprised of the following elements: 1) maintaining custody of samples or other evidence, and 2) documentation of the chain-of-custody for evidence. To document chain-of-custody, an accurate record must be maintained to trace the possession of each sample, or other evidence, from the moment of collection to its introduction into evidence.

3.2 Sample Custody

A sample or other physical evidence is in custody if:

- It is in the actual possession of an investigator;
- It is in the view of an investigator, after being in their physical possession;
- It was in the physical possession of an investigator and then they secured it to prevent tampering; and/or
- It is placed in a designated secure area.

3.3 Documentation of Chain-of-Custody

The following are used to identify and demonstrate how sample integrity is maintained and custody is ensured.

Sample Identification

A stick-on sample label or a tag should be completed for each sample container using waterproof, non-erasable ink as specified in Section 2.2.1.

Sample Seals

If appropriate, samples should be sealed as soon as possible following collection using a custody seal with EPA identification. The sample custodian or project leader will write the date and their initials on the seal. The use of custody seals may be waived if field investigators keep the samples in their custody as defined in Section 3.2, from the time of collection until the samples are delivered to the laboratory analyzing the samples.

Field Sample Custodian

The field sample custodian is the person designated by the project leader to receive and manage custody of samples while in the field, including labeling and custody sealing.

Chain-of-Custody Record

The field Chain-Of-Custody record is used to document the custody of all samples or other physical evidence collected and maintained by investigators. All physical evidence or samples will be accompanied by a Chain-Of-Custody Record. This form may be generated by sample custody management software (Section 5) or it may be a pre-printed multi-sheet carbonless form for hand entry of required information. The Chain-Of-Custody Record documents transfer of custody of samples from the sample custodian to another person, to the laboratory or other organizational elements. The Chain-of-Custody Record will not be used to document the collection of split samples where there is a legal requirement to provide a receipt for samples (see Section 4, Receipt for Samples Form (CERCLA/RCRA/TSCA)). The Chain-Of-Custody Record also serves as a sample logging mechanism for the laboratory sample custodian. A separate Chain-of-Custody Record should be used for each final destination or laboratory used during the investigation.

All information necessary to fully and completely document the sample collection and required analyses must be recorded in the appropriate spaces to complete the field Chain-Of-Custody Record. The following requirements apply to Chain-Of-Custody records generated by either sample custody management software or by hand entry on pre-printed forms:

- All sampling team leaders must sign in the designated signature block.
- One sample should be entered on each line and not be split among multiple lines.
- If multiple sampling teams are collecting samples, the sampling team leader's name should be clearly indicated for each sample.
- The total number of sample containers for each sample must be listed in the appropriate column. Required analyses should be entered in the appropriate location on the Chain-of-Custody Record.
- The field sample custodian, project leader or other designee, and subsequent transferee(s) should document the transfer of the samples listed on the Chain-of-Custody Record. Both the person relinquishing the samples and the person receiving them must sign the form. The date and time that this occurs should be documented in the proper space on the Chain-of-Custody Record. The exception to this requirement would be when packaged samples are shipped with a common carrier. Even though the common carrier accepts the samples for shipment, they do not sign the Chain-of-Custody Record as having received the samples.
- The last person receiving the samples or evidence will be the laboratory sample custodian or their designee(s).

The Chain-of-Custody Record is a uniquely identified document. Once the Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated based upon its inclusion of all of the above information in a legible format.

If chain-of-custody is required for documents received during investigations, the documents should be placed in large envelopes, and the contents should be noted on the envelope. The envelope will be sealed and an EPA custody seal placed on the envelope such that it cannot be opened without breaking the seal. A Chain-Of-Custody Record will be maintained for the envelope. Any time the EPA seal is broken, that fact will be noted on the Chain-Of-Custody Record and a new seal affixed, as previously described in this section.

Physical evidence such as video tapes or other small items will be placed in an evidence bag or envelope and an EPA custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record will be maintained for these items. Any time the EPA seal is broken, that fact will be noted on the Chain-of-Custody Record and a new seal affixed.

EPA custody seals can be used to maintain custody of other items when necessary by using similar procedures as those previously outlined in this section.

Samples should not be accepted from other sources unless the sample collection procedures used are known to be acceptable, can be documented and the sample chain-of-custody can be established. If such samples are accepted, a standard sample label containing all relevant information and the Chain-Of-Custody Record will be completed for each set of samples.

3.4 Transfer of Custody with Shipment

Transfer of custody is accomplished by the following:

- Samples will be properly packaged for shipment in accordance with the procedures outlined in SESD Operating Procedure for Packing, Marking, Labeling and Shipping of Environmental and Waste Samples (SESDPROC-209).
- All samples will be accompanied by the laboratory copy of the Chain-Of-Custody Record. If pre-printed forms are used, the white and pink sheets will be sent. If sample custody management software is used to generate the Chain-Of-Custody Record, the laboratory copy is identified with an "L" in the upper right corner. If multiple coolers are needed for shipment to a particular laboratory, the laboratory copy of the Chain-Of-Custody Record for the entire shipment is placed in a sealed plastic bag in one of the coolers. When shipping samples via common carrier, the "Relinquished By" box should be filled in; however, the "Received By" box should be left blank. The laboratory sample custodian is responsible for receiving custody of the samples and will fill in the "Received By" section of the Chain-of-

Custody Record. One copy of the Record will be provided to and retained by the project leader. After samples have been received and accepted by the laboratory, a copy of the Chain-of-Custody Record, with ASB sample identification numbers, will be transmitted to the project leader. This copy will become a part of the project file.

• If sent by mail, the package will be registered with return receipt requested. If sent by common carrier, an Air Bill should be used. The Air Bill number, shipment tracking number or registered mail serial number will be recorded in the remarks section of the Chain-Of-Custody Record.

4 Receipt for Samples Form (CERCLA/RCRA/TSCA)

4.1 Introduction

Section 3007 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field investigator departs the premises. The Toxic Substances Control Act (TSCA) contains similar provisions. The laws do not require that homeowners or other off-site property owners be given this form.

4.2 Receipt for Samples Form

If necessary, a Receipt for Samples form, using either the pre-printed form or one generated by sample custody management software, is to be used to satisfy the receipt for samples provisions of RCRA, CERCLA and TSCA. The form also documents that split samples were offered and either "Received" or "Declined" by the owner/operator of the facility or site being investigated (if a sample is split with a facility, state regulatory agency or other party representative, the recipient should be provided (if enough sample is available) with an equal weight or volume of sample). All information must be supplied in the indicated spaces to complete the Receipt for Samples form.

- The sampler(s) must sign the form in the indicated location
- Each sample collected from the facility or site must be documented in the sample record portion of the form. The sample station number, date and time of sample collection, composite or grab sample designation, whether or not split samples were collected (yes or no should be entered under the split sample column), a brief description of each sampling location and the total number of sample containers for each sample must be entered.
- The bottom of the form is used to document the site operator's acceptance or rejection of split samples. The project leader must sign and complete the information in the "Split Samples Transferred By" section (date and time must be entered). If split samples were not collected, the project leader should initial and place a single line through "Split Samples Transferred By" in this section. The operator of the site must indicate whether split samples were received or declined and sign the form. The operator must give their title, telephone number and the date and time they signed the form. If the operator refuses to sign the form, the sampler(s) should note this fact in the operator's signature block and initial this entry.



5 Sample Custody Management Software

The container labels and the Chain-of-Custody record should be generated using a sample custody management software to streamline the documentation required by SESD and/or the Contract Laboratory Program (CLP) for sample identification and chain-of-custody. When possible, the sample custody management software should be used during all field investigations. Once the appropriate information is entered into the computer, the software will generate stick-on labels for the sample containers and will generate sample receipt forms and chain-of-custody records for the appropriate laboratory. The advantages to this system include faster processing of samples and increased accuracy. Accuracy is increased because the information is entered only once, and consequently, consistent for the bottle labels, sample receipt forms and chain-of-custody records.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING	PROCEDURE	
Title: Logbooks	ACC \$1.50 (See Aug. Co. Co. Co. Co. Co. Co. Co. Co. Co. Co	
Effective Date: May 30, 2013	Number: SESDPROC-010-R5	
Aut	hors	
Name: Hunter Johnson Title: Environmental Engineer Signature:	Pate: 5/28/13	
Approvals		
Name: Danny France Title: Chief, Enforcement and Investigations I		
Signature: DW W D Name: John Deatrick Title: Chief, Ecological Assessment Branch	, , ,	
Signature: gh Deatril D	Pate: 5/29/13	
Name: Bobby Lewis Title: Field Quality Manager, Science and Eco		
Signature:	Pate: 5/28/13	

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESCPROC-010-R5, <i>Logbooks</i> , replaces SESDPROC-010-R4	May 30, 2013
General: Corrected any typographical, grammatical and/or editorial errors.	
Title Page: Changed author from Liza Montalvo to Hunter Johnson. Changed Enforcement and Investigation Branch Chief from Archie Lee to Danny France. Changed Ecological Assessment Branch Chief from Bill Cosgrove to John Deatrick. Changed Field Quality Manager from Liza Montalvo to Bobby Lewis.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history	
Section 1.2 : Added the following statement: "Requirements for SESD records, which include field logbooks, are outlined in the SESD Operating Procedure for Control of Records (SESDPROC-002)."	
Section 1.4: Updated references	
Section 2.1: Added "bound" to the first sentence.	
Replaced the last sentence of the first paragraph with the following language: "All pertinent field activity information will be recorded contemporaneously when observed or collected to prevent a loss of information."	
Added the second paragraph partially comprised of language from the omitted paragraph from Section 2.2.	
Section2.2: Omitted the first paragraph.	
Added the following language to the first line (formerly the second paragraph): "The following requirements apply to all logbooks :"	
Added Items 1 and 2 and omitted Item 4. Renumbered items as appropriate.	
Added "End of Notes" to the second sentence in item 6 (formerly item 5). Also added the last sentence which states: "Field investigators will draw a diagonal line through blank or unused portions of pages/forms	

that are located prior to the "End of Notes" entry and initial them." Added "and SESD-generated forms" to Item 7 (formerly item 6).	
SESCPROC-010-R4, <i>Logbooks</i> , replaces SESDPROC-010-R3	October 8, 2010
SESCPROC-010-R3, <i>Logbooks</i> , replaces SESDPROC-010-R2	November 1, 2007
SESCPROC-010-R2, <i>Logbooks</i> , Replaces SESDPROC-010-R1	September 25, 2007
SESDPROC-010-R1, Logbooks, Replaces Field Records (Logbooks) SESDPROC-010-R0	August 10, 2007
SESDPROC-010-R0, Field Records (Logbooks), Original Issue	February 5, 2007

TABLE OF CONTENTS

1	Ger	neral Information	5
1	1.1	Purpose	5
	1.2	Scope/Application	
	1.3	Documentation/Verification	
1	1.4	References	5
2		d Records and Documentation Procedures	
2	2.1	General	
2	2.2	Field Data Integrity and Accountability	6
2	2.3	Logbook Entry Information	7
	2.3.	1 General Information Required in All Logbooks	7
	2.3.	2 Information Required for Sample Collection	7
	2.3.		8
	2.3.		

1 General Information

1.1 Purpose

This procedure is to be used by field investigators when documenting pertinent and factual information in logbooks related to field investigations involving sampling and measurement procedures and/or other data collection events.

1.2 Scope/Application

This document describes the various types of information that should be included in the field logbooks used to document field investigations conducted by SESD. Requirements for SESD records, which include field logbooks, are outlined in the SESD Operating Procedure for Control of Records (SESDPROC-002). Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

The procedures found within this document were prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Field Branches Quality Management Plan, SESDPLAN-001, Most Recent Version

Effective Date: May 30, 2013

2 Field Records and Documentation Procedures

2.1 General

Dedicated bound logbooks will be used for field data collection including but not limited to sampling, measurements and observations. Logbook entries should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. All pertinent field activity information will be recorded contemporaneously when observed or collected to prevent a loss of information.

To facilitate accurate and complete documentation of field sampling and measurement activities, SESD-generated forms may be used. In order to be utilized, SESD-generated forms must be bound prior to use and adhere to all requirements outlined in this procedure. In cases where unbound pages/forms are necessary due to project requirements or practicality, approval must be obtained from both the Field Quality Manager and Management. In these cases, the Field Quality Manager and Management will dictate the steps that will be taken to ensure credibility, traceability and defensibility of information collected.

Any deviations from the quality assurance project plan that occur while in the field will be noted in the logbook(s). Logbook entries that may be considered privileged or confidential information will be handled in accordance with the relevant sections of SESD Operating Procedure for Control of Records (SESDPROC-002). The logbooks will be placed in the SESD project file upon transmittal of the final report to the project requestor.

2.2 Field Data Integrity and Accountability

The following requirements apply to **all logbooks**:

- 1. The project's unique identifier (unique identification number(s)) will be included on each page.
- 2. Field personnel will date and number each page. Numbering will be conducted by utilizing a format that incorporates both the current page number and the total number of pages (e.g. "page x of y" or "x/y", where "x" is the current page number and "y" is the total number of pages).
- 3. Observations, data and calculations will be recorded at the time they are made.
- 4. Unless prohibited by environmental conditions, pens with permanent ink will be used to record all data. When environmental conditions do not make it feasible to use permanent ink, entries should be made using a non-smear lead pencil (e.g., 2H or 3H). Upon returning from the field, the project leader will photocopy the penciled section of the logbook and certify, in writing, that the photocopied record is a true copy of the original logbook entry. The photocopy will be included in the project file.

SESD Operating Procedure

Logbooks

Page 6 of 9

SESDPROC-010-R4

Logbooks(010)_AF.R4

- 5. Entries will be legible and contain pertinent, accurate and inclusive documentation of project activities.
- 6. Upon completion of the field investigation, the end of project entries in the logbook and/or bound forms will be clearly indicated. This may be accomplished by noting "End" or "End of Notes" on the last page of notes and dating and initialing the notation. Field investigators will draw a diagonal line through blank or unused portions of pages/forms that are located prior to the "End of Notes" entry and initial them.
- 7. In order to demonstrate continuity of the project and to preclude questioning of the integrity of the data collection process, pages and SESD-generated forms should not be removed from bound logbooks under any circumstances.
- 8. Data or other information that has been entered incorrectly will be corrected by drawing a line through the incorrect entry and **initialing and dating** the lined-through entry. Under no circumstances should the incorrect material be erased, made illegible or obscured so that it cannot be read.
- 9. If pre-printed adhesive labels are used in logbooks or bound forms to facilitate organization of information entry, the field investigator who is responsible for taking notes will sign the label with the signature beginning on the label and ending on the page of the logbook such that the label cannot be removed without detection.

2.3 Logbook Entry Information

2.3.1 General Information Required in All Logbooks

The following information will be included either on the front cover or the first page of **all logbooks**:

- 1. Project name
- 2. Project location
- 3. Project identification number
- 4. Project leader (full name)
- 5. Sample team leader (full name) and initials
- 6. Sample team member(s) (full name) and initials

2.3.2 Information Required for Sample Collection

In addition to the information listed in Section 2.3.1, the following information will be included in all logbooks when **samples** are collected:

- 1. Applicable SESD Operating Procedures for field sampling
- 2. Date and time of collection
- 3. Station identification
- 4. Sample identification

SESD Operating Procedure Page 7 of 9 SESDPROC-010-R4
Logbooks Logbooks(010)_AF.R4

Effective Date: May 30, 2013

- 5. Method of collection
- 6. Number and type of containers
- 7. Sample collection equipment
- 8. SESD equipment identification number, if applicable
- 9. Physical description of sample
- 10. Matrix sampled
- 11. Sample team member duties (calibration, collection, deployment, etc.)
- 12. Sample preservation (including ice), if applicable
- 13. Conditions that may adversely impact quality of samples, if applicable (rain, wind, smoke, dust, extreme temperature, etc.)
- 14. GPS coordinates (Non-logging GPS units), if applicable
- 15. Location of electronic data file backups, if applicable
- 16. Monitoring of condition of ice in coolers or sampler
- 17. Other pertinent information.

2.3.3 Information Required for Field Measurements

In addition to the information listed in Section 2.3.1, the following information will be included in all logbooks when **measurements** are conducted:

- 1. Applicable SESD Operating Procedures for field measurement
- 2. Date and time of measurement or deployment
- 3. Sample identification, if appropriate
- 4. Station identification
- 5. Sample measurement equipment
- 6. SESD sample measurement equipment identification number
- 7. Manufacturer name, lot number and expiration date of all buffers and standards*
- 8. Calibration information, including before and after calibration readings*
- 9. Meter end check information
- 10. Deployment depth and total depth, if applicable
- 11. Pinger identification number and frequency for deployed equipment, if applicable
- 12. Time of retrieval for deployed equipment, if applicable
- 13. Physical description of matrix
- 14. Sample team member duties (calibration, collection, deployment, etc.)
- 15. Measurement values for non-logging equipment
- 16. GPS coordinates (non-logging GPS units), if applicable
- 17. Location of electronic data file backups, if applicable
- 18. Ambient air temperature, where applicable
- 19. Conditions that may adversely impact quality of measurement (Ex. temperature extremes)
- 20. Maintenance performed, if applicable

SESD Operating Procedure

Logbooks

- 21. Meter malfunctions, if applicable
- 22. Other pertinent information

2.3.4 Additional Information for Inclusion

The following information may be included in logbooks as appropriate:

- 1. Maps/sketches
- 2. Photographic or videographic log
- 3. Process diagrams

SESD Operating Procedure Page 9 of 9 SESDPROC-010-R4

Logbooks

^{*} Entry of calibration information in logbooks is only required for calibrations conducted in the field. All calibrations conducted at the Field Equipment Center or SESD laboratory will be recorded in the appropriate equipment tracking logbook.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

OF ERATING TROCEDURE	
Title: Field Sampling Quality C	Control
Effective Date: April 26, 2017	Number: SESDPROC-011-R5
	Authors
Name: Timothy Simpson Title: Life Scientist Signature: The Manual Simpson	Date: 04/20/2017
A	pprovals
Name: John Deatrick Title: Chief, Field Services Branch	
Signature: John Deatrick	Date: 4/24/17
Name: Hunter Johnson Title: Field Quality Manager, Science an	d Ecosystem Support Division
Signature:	Date: 4/20/17

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-011-R5, Field Sampling Quality Control, replaces SESDPROC-011-R4	April 26, 2017
Cover Page: SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Bobby Lewis to Hunter Johnson.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
General: Corrected any typographical, grammatical and/or editorial errors. Changed name of Enforcement and Investigations Branch to Field Services Branch. Removed references to Ecological Assessment Branch. Added Section 2.9 to the Table of Contents.	
Section 1.4.6: Added definition for Organic-Free Water	
Section 3.5: Changed volume needed for soil MS/MSD samples from triple to double volume.	
Section 4.1: Modified statement to read: Each lot of chemical preservative will be tested for the appropriate analytes by either FEC Staff or the Branch QAO.	
SESDPROC-011-R4, Field Sampling Quality Control, replaces SESDPROC-011-R3	February 5, 2013
SESDPROC-011-R3, Field Sampling Quality Control, replaces SESDPROC-011-R2	October 15, 2010
SESDPROC-011-R2, Field Sampling Quality Control, replaces SESDPROC-011-R1	January 28, 2008
SESDPROC-011-R1, <i>Field Sampling Quality Control</i> , replaces SESDPROC-011-R0.	October 19, 2007
SESDPROC-011-R0, Field Sampling Quality Control, Original Issue	February 5, 2007

TABLE OF CONTENTS

1	Ger	neral Information	4
	1.1	Purpose	4
	1.2	Scope/Application	4
	1.3	Documentation/Verification	4
	1.4	Definitions	4
	1.4.	1 Sample	4
	1.4.	2 Variability	4
	1.4.	3 Grab Sample	5
	1.4.	4 Composite Sample	5
	1.4.	5 De-ionized Water	6
	1.4.	6 Organic-Free Water	6
	1.4.	7 Branch Field Equipment Manager	6
	1.5	References	
2	Fiel	d Sampling Quality Control Considerations	8
	2.1	Experience Requirements	
	2.2	Traceability Requirements	8
	2.3	Chain-of-Custody	8
	2.4	Sampling Equipment Construction Material	8
	2.5	Sample Preservation	9
	2.6	Sample Collection Precautions	9
	2.7	Sample Handling and Mixing	10
	2.8	Special Handling of Samples for Volatile Organic Compounds Analysis	11
	2.9	Sample Storage and Transport	10
3	Qua	ality Control Samples	13
	3.1	Control Sample	13
	3.2	Background Sample	
	3.3	Variability Samples	13
	3.3.	T · · · · · · · · · · · · · · · · · · ·	
	3.3.	1 , 1	
	3.3.	1 0	
	3.4	Spikes	17
	3.5	Matrix Spike/Matrix Spike Duplicate Samples for Water and Soil Samples for	
		Organic Compounds Analyses	. 17
	3.6	Matrix Spike/Matrix Spike Duplicate Samples for Water and Soil Samples for	
		Inorganic Analyses	
	3.7	Special Quality Control Procedures for EPA Contract Laboratories	18
	3.8	Special Quality Control Procedures for Dioxins and Furans	18
4		ernal Quality Control Procedures	
	4.1	Traceability Requirements	20
	4.2	Specific Quality Control Checks	
	4.3	Quality Control for Special Order Equipment and Supplies	22
	4.4	Quality Control Evaluation and Corrective Action	
	4.4.	1 Quality Assurance Reports	23

Effective Date: April 26, 2017

1 General Information

1.1 Purpose

This document describes procedures established to ensure the quality of SESD field sampling activities, including Field Equipment Center (FEC) operations involving preparation of sampling and support equipment for field operations. Collectively, these procedures ensure that field sampling teams are provided with equipment that is suitable for sampling use, and that field sampling is conducted using proper procedures, resulting in the collection of representative samples. Strict adherence to these procedures forms the basis for an acceptable field sampling quality assurance program.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators when collecting and handling samples in the field and when preparing sampling equipment for SESD field investigations. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 Definitions

1.4.1 *Sample*

A part of a larger lot, usually a volume, area, period or population.

1.4.2 Variability

The range or "distribution" of results around the mean value obtained from samples within a population. There are three types of variability which should be measured or otherwise accounted for in field sampling, depending on the data quality objectives (DQO) for the study:

1. Temporal Variability

Temporal variability is the range of results due to changes in contaminant

SESD Operating Procedure SESDPROC-011-R5

Page 4 of 23

Field Sampling Quality Control

Field Sampling Quality Control (011)_AF.R5

Effective Date: April 26, 2017

concentrations over time. An example would be the range of concentrations obtained for a given parameter in wastewater samples collected at different times from an outfall where contaminant concentrations vary over time.

2. Spatial Variability

Spatial variability is the range of results due to changes in contaminant concentrations as a function of their location. An example would be the range of concentrations obtained for a given parameter in surface soil from a site where discreet "hot spots" are present due to localized releases of contaminants on otherwise uncontaminated soil.

3. Sample Handling Variability

Sample handling variability is the range of results due to the sample collection and handling techniques used by the sampler. This variability manifests itself as a positive bias due to errors such as unclean sampling equipment, cross contamination, etc., or a negative bias due to improper containers or sample preservation.

1.4.3 Grab Sample

An individual sample collected from a single location at a specific time or period of time. Grab samples are generally authoritative in nature.

1.4.4 Composite Sample

A sample collected over a temporal or spatial range that typically consists of a series of discrete, equal samples (or "aliquots") which are combined or "composited." A composite sample represents the average characteristics of the population under consideration. Four types of composite samples are listed below:

- 1. Time Composite (TC) a sample comprised of a varying number of discrete samples or "aliquots" collected at equal time intervals during the compositing period. The TC sample is typically used to sample wastewater or streams.
- 2. Flow Proportional Composite (FPC) A sample consisting of discrete samples or "aliquots" collected at a rate proportional to flow. The aliquots are collected during the compositing period by either a time-varying/constant volume (TV/CV) method proportioning") ("automated flow or method time-constant/varying volume ("manual (TC/VV) proportioning"). The TV/CV method is typically used with automatic samplers that are paced by a flow meter. The TC/VV method is a manual method that individually proportions a series of discretely collected aliquots. The FPC is

typically used when sampling wastewater.

- 3. Areal Composite a sample composited from individual, equal aliquots collected on an areal or horizontal cross-sectional basis. Each aliquot is collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from within grids.
- 4. Vertical Composite a sample composited from individual, equal aliquots collected from a vertical cross section. Each aliquot is collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes, and estuaries.

1.4.5 De-ionized Water

Tap water that has been treated by passing it through a standard de-ionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard Inductively Coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. De-ionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for de-ionized water.

1.4.6 Organic-Free Water

Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

1.4.7 Branch Field Equipment Manager

Staff, designated by management, who are responsible for ensuring that the procedures for Equipment Inventory and Management are followed. At least one Branch Field Equipment Manager will be designated for the Field Services Branch (FSB).

1.5 References

SESD Safety, Health and Environmental Management Program (SHEMP) Manual, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005-most recent version)

SESD Operating Procedure for Competency and Proficiency Testing, (SESDPROC-006, most recent version)

SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108-most recent version)

SESD Operating Procedure for Sediment Sampling (SESDPROC-200-most recent version)

SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205-most recent version)

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206-most recent version)

SESD Operating Procedure for Soil Sampling (SESDPROC-300-most recent version)

SESD Operating Procedure for Waste Sampling (SESDPROC-302-most recent version)

USEPA Region 4 Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM), November 2001

USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version

Loan-In Form (SESDFORM-011, most recent version)

SESD Operating Procedure for Packing, Marking, Labeling, and Shipping of Environmental and Waste Samples (SESDPROC-209, most recent version)

SESD Operating Procedure for Training (SESDPROC-007-most recent version)

SESD Operating Procedure for Corrective Action (SESDPROC-009-most recent version)

SESD Guidance for Design and Installation of Monitoring Wells (SESDGUID-101-most recent version)

SESD Operating Procedure

Page 7 of 23

Field Sampling Quality Control

SESDPROC-011-R5

Field Sampling Quality Control (011)_AF.R5

2 Field Sampling Quality Control Considerations

This section provides guidelines for establishing quality control procedures for sampling activities. Strict adherence to all of the standard operating procedures outlined in this subsection forms the basis for an acceptable sampling quality assurance program.

2.1 Experience Requirements

There is no substitute for field experience. This field experience will be gained by on-the-job training using the "buddy" system. Each new investigator will accompany an experienced employee on as many different types of field studies as possible. During this training period, the new employee will be permitted to perform all facets of field investigations, including sampling, under the direction and supervision of senior investigators. Specific requirements covering experience, competency and proficiency are found in the SESD Operating Procedure for Competency and Proficiency Testing (SESDPROC-006) and SESD Operating Procedure for Training (SESDPROC-007).

2.2 Traceability Requirements

All sample collection and measurement activities will be traceable through field records to the person collecting the sample or making the measurement. All maintenance and calibration records for sampling and measurement equipment (where appropriate) will be kept so that they are similarly traceable. The SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108) contain specific procedures to be followed that ensure traceability.

2.3 Chain-of-Custody

Specific chain-of-custody procedures are included in SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005). These procedures will ensure that evidence collected during an investigation will withstand scrutiny during litigation. To assure that procedures are being followed, it is recommended that field investigators or their designees audit chain-of-custody entries, tags or labels, field notes, and any other recorded information for accuracy. Additionally, the SESD FQM will randomly conduct reviews of project files to ensure that quality procedures are being followed.

2.4 Sampling Equipment Construction Material

Sampling equipment construction materials can affect sample analytical results. Field investigators will ensure the sample equipment construction material will not introduce contaminants to the sample being collected.

Effective Date: April 26, 2017

2.5 Sample Preservation

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for routine analyses of samples collected are found in the USEPA Region 4 Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM). Chemical preservatives used will be supplied by the Region 4 laboratory or purchased by the Branch Field Equipment Manager. All samples requiring preservation should be preserved immediately upon collection in the field. Records of sample preservation, including ice, will be documented in the field log books.

Samples that **should not** be preserved in the field are:

- 1. Those collected within a hazardous waste site that are known or thought to be highly contaminated with toxic materials which may be highly reactive. Barrel, drum, closed container, spillage or other source samples from hazardous waste sites are not to be preserved with any chemical.
- 2. Those that have extremely low or high pH or samples that may generate potentially dangerous gases if they were preserved according to the ASBLOQAM.

All samples preserved with chemicals will be clearly identified by indication on the sample tag or label that the sample is preserved. If samples normally requiring preservation were not preserved, field records should clearly specify the reason. Samples shipped by air will not be preserved with nitric acid, hydrochloric acid, sodium hydroxide or sulfuric acid in excess of the amount specified in the ASBLOQAM.

2.6 Sample Collection Precautions

In order to prevent cross-contamination during sample collection, the following precautions will be taken:

- 1. A clean pair of new, non-powdered, disposable latex or nitrile gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come into contact with the media being sampled.
- 2. Sample containers for source samples or samples suspected of containing high concentrations of contaminants will be placed in separate plastic bags immediately after collecting, tagging, etc.
- 3. If possible, environmental (low concentration) samples and source or waste samples (high concentration) should be collected by different field teams. If different field teams cannot be used, all environmental samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or

SESD Operating Procedure SESDPROC-011-R5

highly contaminated samples should never be placed in the same ice chest as environmental samples. Ice chests or shipping containers for source or waste samples or any samples suspected to contain high concentrations of contaminants will be lined with new, clean, plastic bags.

- 4. If possible, one member of the field sampling team should record all of the field notes, collect GPS data, etc., while the other members collect the samples.
- 5. When sampling surface water and sediment at the same location, the water sample should always be collected before the sediment sample is collected.
- 6. Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.
- 7. Investigators should use equipment constructed of Teflon®, stainless steel, or glass that has been properly pre-cleaned according to either the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or the SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of plastic or PVC should not be used to collect samples for trace organic compounds analyses.
- 8. Field investigators should ensure the sample containers they are using have been verified as suitable for the analyses that will be conducted on the samples through the quality control procedures discussed in Section 4 of this procedure.

Upon returning from the field, un-used sample containers will be examined by project leaders to determine whether bottles should be discarded, recycled or re-shelved for use on other projects. A load-in form (SESDFORM-011) will be completed and signed by project leaders to identify the future use of sample containers returning from the field. Opened boxes of sampling containers that can be re-used, will be segregated from sealed boxes of new containers.

Opened bags of latex or nitrile gloves returning from the field will be segregated from unopened gloves and will not be re-used for sample collection on other projects.

2.7 Sample Handling and Mixing

Once a sample has been collected, it may have to be transferred into separate containers for different analyses. Sample transfer should be done as soon as possible. If necessary, aqueous samples may be collected into a single, larger container for homogenization and transferred into individual sample containers. However, aqueous samples collected for

SESD Operating Procedure SESDPROC-011-R5

Effective Date: April 26, 2017

Page 10 of 23 Field Sampling Quality Control

Field Sampling Quality Control (011)_AF.R5

volatile organic compounds, oil and grease, bacteria, sulfides and phenols analyses may not be transferred using this procedure.

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is representative of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- 1. The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
- 2. Two quarters should then be mixed to form halves.
- 3. The two halves should be mixed to form a homogenous matrix.

This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction and occasionally turning the material over.

2.8 Special Handling of Samples for Volatile Organic Compounds Analysis

Water samples to be analyzed for volatile organic compounds should be stored in 40-ml septum vials with screw cap and Teflon®-silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the field investigation.

The vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a convex meniscus. The cap is then applied and some overflow is lost, but the air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample recollected.

Soil and sediment samples for VOC analyses should be collected and handled as specified in the SESD Operating Procedure for Soil Sampling (SESDPROC-300), Waste Sampling (SESDPROC-302) or the SESD Operating Procedure for Sediment Sampling (SESDPROC-200). Soil and sediment samples collected for VOC analyses should <u>not</u> be mixed.

SESD Operating Procedure SESDPROC-011-R5

Page 11 of 23 Field Sampling Quality Control

Field Sampling Quality Control (011)_AF.R5

2.9 Sample Storage and Transport

After collection, sample handling should be minimized. Field investigators should use extreme care to ensure that samples are not contaminated during storage. Environmental and waste samples are typically stored in coolers. To reduce the risk of cross contamination, smaller sample containers such as 8 ounce glass jars, 40 ml VOA vials, and one-liter amber bottles should be placed inside of sealed, plastic bags before being placed in the cooler. If ice is required for preservation of the samples, the ice should be contained in a plastic bag or some equivalent container to prevent the potential for cross contamination of the samples by water produced from melting ice. If ice is used, the coolers should be checked regularly and water should be drained as needed. Custody of samples will be maintained according to the SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005).

Samples will either be transported to the analytical laboratory by field investigators or shipped by common carrier. Shipping of samples will be conducted in accordance with the SESD Operating Procedure for Packing, Marking, labeling, and Shipping of Environmental and Waste Samples (SESDPROC-209).

Effective Date: April 26, 2017

3 Quality Control Samples

Quality control samples are collected during field studies for various purposes, among which are to isolate site effects (control samples), to define background conditions (background sample), and to evaluate field/laboratory variability (spikes and blanks, trip blanks, duplicate, split samples, etc.).

3.1 Control Sample

A control sample is typically a discrete grab sample collected to isolate a source of contamination. Isolation of a source could require the collection of both an upstream sample at a location where the medium being studied is unaffected by the site being studied, as well as a downstream control which could be affected by contaminants contributed from the site under study.

3.2 Background Sample

A background sample (usually a grab sample) is collected from an area, water body or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

3.3 Variability Samples

Variability may be defined as a variation in concentrations of compounds or analytes across a site or area of investigation or variations, across time, of waste streams or surface water bodies. Variation can also be introduced during sample handling. The following procedures are used to assess and evaluate variability. When appropriate, spatial duplicate grab and/or composite samples should be collected during investigations and studies in accordance to the project DQOs. In general, no more than ten percent of all samples should be collected as spatial duplicates.

3.3.1 Spatial Variability Duplicate

The following spatial duplicate sampling procedures should be used during the collection of samples as a measure of variability within the area represented by the sample. These samples should be collected at the same time, using the same procedures, the same type of equipment, and in the same types of containers as the original samples. They should also be preserved in the same manner and submitted for the same analyses as the required samples.

Spatial variability duplicate samples are typically collected during investigations where samples are collected from grids that are positioned at fixed intervals over the study area and a sample collection pattern is established within the grids. Spatial variability duplicate samples are collected using the same compositing pattern as the original sample and are collected within the same general area of

representativeness, however the pattern is shifted relative to the original aliquot locations. This amount and direction of shift for the duplicate sample is dependent upon the size of the grid or area being sampled and should be specified in the QAPP for the investigation. Data from spatial duplicates will be examined by the investigation project leader to determine if the observed spatial variability is acceptable, based on the investigation or study objectives.

3.3.2 Temporal Variability Duplicate

When appropriate, temporal variability at a given sampling location will be measured by collecting temporal duplicate samples. These samples will be collected from the same sampling location, using the same techniques and the same type of equipment, but at a time different from the original sample. The time selected for the temporal duplicate sample will be similar to the time or span of time specified for the original sample in the project work plan. Data from temporal duplicates will be examined by the project leader to determine if samples represent the time span intended in the project work plan.

3.3.3 Sample Handling Variability

The effectiveness of sample handling techniques will be measured by collecting split and blank samples.

Split Samples

Split samples will be collected by initially collecting twice as much volume as is normally collected. The material will be apportioned, after mixing, if appropriate, into two sets of containers. Both sets of containers will be submitted for analyses with one set designated as an "original sample," the other designated as a "split sample." Data from the split samples will be examined by the project leader to assess sample handling variability. On large studies (more than 20 samples collected), a minimum of 5 percent, but no more than 10 percent, of all samples will be collected as split samples unless required by site data quality objectives.

Blank Samples

The following blank samples will be prepared by the laboratory and obtained by the project leader prior to traveling to a sample site.

1. Water Sample VOC Trip Blank - A water sample VOC trip blank is required for every study where water samples are collected for VOC analysis. Sealed preserved (or unpreserved, if unpreserved vials were used during the investigation) 40-ml VOC vials will be transported to the field. Two sealed VOC vials will be submitted per trip blank sample. At least one trip blank sample will be submitted per sample shipment. Trip blanks will be prepared by lab personnel. Investigators should submit their request for trip blanks at least one week in advance of scheduled field investigations and inspections and never

SESD Operating Procedure

Page 14 of 23

Field Sampling Quality Control

SESDPROC-011-R5

Field Sampling Quality Control (011)_AF.R5

(except in emergency situations) less than two days in advance of scheduled field investigations and inspections. These samples should not be picked up earlier than the morning of departure for the scheduled inspection/investigation. These trip blanks will be handled and treated in the same manner as the water samples collected for volatile organic compounds analysis on that particular study. These samples will be clearly identified on sample labels and Chain-of-Custody Records as trip blanks.

The following blanks are prepared in the field:

1. Sample Preservative Blanks - SESD will generally use chemical preservatives stored in individual single-use vials. The chemical preservative will be tested prior to use for the appropriate analytes. The use of pre-tested, single-use vials eliminates the need to routinely collect preservative blanks in the field. If the preservatives are stored in containers that will be used to preserve multiple samples, blanks will be collected to evaluate the potential for cross-contamination resulting from the preservation process. If preservative blanks are collected, sample containers will be filled with de-ionized water by SESD personnel and transported to the field and preserved and submitted for the same analyses as the other inorganic samples collected. These samples will be clearly identified as preservatives blanks on sample labels and the Chain-Of-Custody Record(s). At least one preservative blank for each type of preserved sample should be collected at the end of routine field investigations. In addition, one preservative blank will be collected for each multi-use bottle of preservative used.

Note: The deionized water will be generated from a water treatment unit provided by the SESD laboratory.

2. Equipment Rinsate Blanks - Equipment rinsate blanks will be collected whenever field decontamination of equipment to be re-used in sampling activities is performed.

When field cleaning of equipment is required during a sampling investigation, a piece of the field-cleaned equipment will be selected for collection of a rinse

blank. At least one rinse blank will be collected during each week of sampling operations. After the piece of equipment has been field cleaned and prior to its being used for sample operations, it will be rinsed with organic-free water. The rinse water will be collected and submitted for analyses of all constituents for which normal samples collected with that piece of equipment are being analyzed.

- 3. Organic-Free Water System Blanks When using a portable organic-free water generating system in the field, a sample of the water generated by the system will be collected at least once during each week of operations. Based on the objectives of the study or investigation, it may be appropriate to collect a sample of the raw source water. The collected water sample will be submitted for analyses of all constituents for which normal samples are being analyzed.
- 4. Material Blanks When construction materials are being used on a site in such a way as to have a potential impact on constituent concentrations in the sample, a sample of each material will be submitted for analysis.

Note: For drilling operations where materials are shipped directly to the site from the supplier, see SESD Guidance for Design and Installation of Monitoring Wells (SESDGUID-101) for material blank collection and reporting requirements.

- 5. Automatic Sampler Blanks In general, cleaning procedures outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) should be adequate to ensure sample integrity. However, it is the standard practice of the Field Services Branch to submit automatic sampler blanks for analyses when automatic samplers are used to collect samples for organic compounds and metals analyses. Automatic sampler blanks for other standard analyses may be submitted in the event of a special investigation (e.g., criminal or civil).
- 6. Field Blank A field blank is a sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected (for example air-borne dust or organic vapors which could contaminate a soil sample). Organic-free water is taken to the field in sealed containers or generated on-site. The water is poured into the appropriate sample containers at pre-designated locations at the site. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.
- 7. Temperature Blank A temperature blank is a container of water shipped with each cooler of samples requiring preservation by cooling to 6°C (ice). The temperature of the blank is measured at the time of sample receipt by the laboratory. No temperature blank is necessary for waste samples since waste samples do not require ice for preservation.

- 8. Wipe Sample Blank A wipe sample blank is a sample of the material and solvent used for collecting wipe samples. The blank is handled, packaged and transported in the same manner as all other wipe samples with the exception that it is not exposed to actual contact with the sample medium.
- 9. Water Filter Blank When filters are used for sampling a dissolved constituent, deionized water should be run through at least one filter from each lot and the filtered water submitted for the same analyses. When filters are used for chlorophyll sampling, the filter should be prepared using de-ionized water and submitted for the same chlorophyll analysis.

3.4 Spikes

Spike samples are used to measure bias due to sample handling or analytical procedures. Spike samples are typically used by SESD to evaluate the performance of contract laboratories and are shipped directly to the CLP laboratory by the ESAT contractor.

3.5 Matrix Spike/Matrix Spike Duplicate Samples for Water and Soil Samples for Organic Compounds Analyses

Matrix spike and matrix spike duplicate (MS/MSD) samples will be submitted to the laboratory for volatile organic compounds, extractable organic compounds, pesticides/PCBs and/or herbicides analyses from at least one sampling location per project and laboratory used. One MS/MSD sample should be collected per 20 samples per media collected.

Additional volume will be required for the soil MS/MSD samples. Semi-volatile organic compounds, pesticides, and PCB analyses of soil/sediment samples require the collection of one additional eight ounce glass jar. For VOC soil/sediment samples, double volume, i.e., six En Cores® or six 40 ml vials with syringe collected sample, is needed for the MS/MSD samples.

Additional volume will be required for the water MS/MSD samples. For routine full scan analysis, i.e., extractable organic compounds, pesticides and PCBs, four one-liter amber containers provide the required sample volume. Eight containers, therefore, should be submitted for the MS/MSD sample. For VOC water samples, a total of six 40 ml vials should be collected.

MS/MSD samples should be collected from a location expected to be relatively free from contamination, since the samples will be used for laboratory quality control purposes. The duplicate samples should be clearly identified as "Duplicate Sample for Matrix Spike" or "MS/MSD" on the Chain-Of-Custody Record, in the field logbook and on the Contract Laboratory Program (CLP) Traffic Report Form (if appropriate). This procedure will be followed for all projects where water samples are collected for the indicated analyses. For

SESD Operating Procedure

Page 17 of 23

Field Sampling Quality Control

SESDPROC-011-R5

Field Sampling Quality Control (011)_AF.R5

non-routine sampling events, the Region 4 SESD laboratory should be consulted for specific sample volume and container requirements.

3.6 Matrix Spike/Matrix Spike Duplicate Samples for Water and Soil Samples for Inorganic Analyses

A matrix spike sample and a duplicate sample (MS/MSD) will be submitted to the laboratory for inorganic analyses from at least one sampling location per project and laboratory used. One matrix spike and duplicate sample should be collected per 20 samples per media collected per laboratory.

Soil/sediment and water samples collected for inorganic analyses will normally have sufficient sample volume to perform the matrix spike analyses without requiring the collection of extra sample volume. The project leader should designate a sample, typically one considered to be representative of background or relatively uncontaminated conditions, as the matrix spike sample. For water samples, the sample volume collected will normally provide adequate volume for the MS/MSD analyses.

MS/MSD samples should be collected from a location expected to be relatively free from contamination, since the samples will be used for laboratory quality control purposes. MS/MSD samples should be clearly identified as "Duplicate Sample for Matrix Spike" or "MS/MSD" on the Chain-Of-Custody Record, in the field logbook and on the Contract Laboratory Program (CLP) Traffic Report Form (if appropriate). This procedure will be followed for all projects where water samples are collected for the indicated analyses. For non-routine sampling events, the Region 4 SESD laboratory should be consulted for specific sample volume and container requirements.

3.7 Special Quality Control Procedures for EPA Contract Laboratories

On a case-by-case basis, field investigators may be required to collect split samples (or duplicate samples if appropriate) for analyses by either the Region 4 SESD laboratory or contract laboratories. The split samples are to be submitted to the Region 4 laboratory using established procedures. The contract laboratory involved will not be notified that samples were split, i.e., there should be no indication on Chain-Of-Custody Records or CLP Traffic Report Forms submitted to the contract laboratories that these samples were split with the Region 4 SESD laboratory.

3.8 Special Quality Control Procedures for Dioxins and Furans

The Region 4 laboratory does <u>not</u> conduct in-house analyses for dioxins and furans. Dioxin and furans analyses are conducted by contract laboratories. The Region 4 laboratory may accept environmental samples (soil, sediment, groundwater and surface water) suspected of being contaminated with polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF), as long as suspected PCDD and PCDF contamination is not due to RCRA hazardous waste classified as F020-023 and/or F026-

SESD Operating Procedure

Page 18 of 23

Field Sampling Quality Control

SESDPROC-011-R5

Field Sampling Quality Control (O11)_AF.R5

028. If these environmental samples are not contaminated with an F020-023 and/or F026-028 waste, it may be analyzed for parameters other than dioxin and furans. Environmental samples known or suspected to be contaminated with the RCRA hazardous waste F020-023 and or F026-028 will not be accepted.

NOTE: Environmental samples suspected of being contaminated with RCRA hazardous waste classified in 40 CFR, 261.31 as F032 will be accepted. The F032 waste is defined as wastewaters (except those that have not come into contact with process contaminants), process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that currently use or have previously used chlorophenolic formulations. The F032 listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and or pentachlorophenol. Prior to a sampling event, the project leaders should consult with the Analytical Services Branch Sample Control Coordinator to determine if the Region 4 laboratory can accept the samples. The Region 4 SESD laboratory should also be consulted for the current quality control procedures for dioxins and furans samples prior to a sampling investigation.

Effective Date: April 26, 2017

4 Internal Quality Control Procedures

The focus of this section is on Field Equipment Center (FEC) operations involving preparation of sampling and support equipment for field operations, as well as, field data generated under the specific sample collection quality control procedures discussed in Section 2. Quality control checks of these operations ensure that field sampling teams are provided with equipment that is suitable for sampling use, and that field sampling is conducted using proper procedures.

4.1 Traceability Requirements

Records, will be kept by designated SESD staff or FEC personnel documenting the dates of operations and the person performing operations for the following:

- 1. Organic-Free Water System Maintenance (FEC System) Maintenance on the FEC organic-free water system will be performed at least once per 180 days.
- 2. Air Monitoring Safety Instrumentation Checkouts Pre-loadout checks on safety monitoring instrumentation will be recorded each time they are performed. Discrepancies will be immediately reported to the Branch Safety Officer.
- 3. Self Contained Breathing Apparatus (SCBA) Checkouts Pre-loadout checks on SCBAs will be recorded when they are performed. SCBA checkouts will be performed at least once per calendar quarter in the absence of loadout requests. Any discrepancies will be reported immediately to the Branch Safety Officer.
- 4. Other Equipment Maintenance Maintenance performed on equipment other than that listed above will be accordance to the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). All required repairs will be reported to appropriate Branch Field Equipment Manager.
- 5. Tubing, Sampling Containers and Latex Gloves The Field Services Branch Quality Assurance Officer (FSB QAO) is responsible for conducting verification sampling for tubing, sample containers, and latex gloves that are used during field investigations. Upon receipt, the tubing, containers and gloves are placed in the quarantine room at the FEC. A record is kept of the lot numbers for each shipment received. The FSB QAO, or designee, will collect blank samples from tubing, containers and gloves within each lot received and will review the results to ensure the sample containers and gloves are suitable for use during field investigations. Once the supplies are deemed suitable, the FSB QAO will release the items for use.
- 6. Chemical preservatives commercially purchased will be tested prior to use. Each lot of chemical preservative will be tested for the appropriate analytes by either the

Effective Date: April 26, 2017

Branch Field Equipment Manager or the FSB QAO. Once released by FSB QAO, the preservatives can be used in the field.

7. Equipment - All equipment cleaned and wrapped for field use will be marked with the date on which preparation was completed. Equipment will be stored at the FEC in specified areas to minimize the risk of contamination while awaiting use.

4.2 Specific Quality Control Checks

When collecting samples during field investigations, it is necessary to take measures to prevent cross contamination to ensure the integrity of the data generated. The field branches conduct verification sampling of sample containers, gloves, sampling equipment, tubing and water utilized during field investigations as one of these measures. At least once per calendar quarter, the FSB QAO will conduct the following checks and issue a written report to the Field Quality Manager with the results.

- 1. Collect and submit for analyses samples of each new lot of containers received, Bottles from each lot will be tagged and sealed, then submitted for the following analyses:
 - 1. 1-liter Amber extractable organics, pesticides, and PCBs.
 - 2. 8-oz. Clear Glass metals, cyanide, extractable organics, pesticides, PCBs, and volatile organic compounds.
 - 3. 1-Liter Polyethylene metals and cyanide.

NOTE: In addition to the quality control checks listed above, samples may be collected during field investigations for classical inorganic parameters such as nitrates, nitrites, sulfides, etc. Due to the detection levels generally required for these parameters, it is unlikely that cross contamination may occur in association with the sample containers and sampling equipment used during sample collection. Therefore, classical inorganic analyses are not conducted as part of the routine quality control checks. If the data quality objectives require additional quality control checks, bottles will be submitted to the laboratory for analyses.

- 2. Collect and submit for analyses a rinsate blank for each new lot of latex or nitrile gloves received during the calendar quarter. Samples will be collected as rinse blanks using organic-free water. The rinsate will be submitted for analyses of VOCs, metals, cyanide, extractable organics, pesticides and PCBs. A new glove will be rinsed for each parameter (e.g., one glove for the VOC sample, another glove for metals, etc.) to avoid dilution of potential contaminants on the gloves. Water for the VOC samples should be provided by the ASB laboratory.
- 3. Collect and submit for analyses a sample of water from the FEC organic-free water system. The sample will be submitted for analyses of VOCs, metals, cyanide, extractable organics, pesticides and PCBs.

- 4. Collect and submit for analyses a rinsate blank of at least one piece of sampling or sample related equipment stored at the FEC. The sample will submitted for analyses of VOCs, metals, cyanide, extractable organics, pesticides and PCBs. Water for the VOC samples should be provided by the ASB laboratory.
- 5. Collect and submit for analyses a rinsate blank for each new lot of Silastic® or Tygon® tubing used in peristaltic pump head. The sample will be submitted for metals and cyanide analysis.
- 6. Teflon® tubing Collect and submit for analyses a rinsate blank for each new lot of Teflon® tubing received. Rinse blanks will be collected through the Teflon tubing. The sample will be submitted for metals, cyanide, extractable organics, volatile organic compounds, pesticides and PCBs. Water for the VOC samples should be provided by the ASB laboratory.

4.3 Quality Control for Special Order Equipment and Supplies

Some equipment and supplies ordered for specific projects are received in what can be considered ready to use condition. In order to ensure the integrity of these materials, an equipment rinsate blank will be collected from at least one item in each lot. The equipment and supplies will not be used until the QAO has reviewed the analytical data for the blanks and released the items.

4.4 Quality Control Evaluation and Corrective Action

All field investigation reports will contain a clearly identified section where the results for all field generated quality control (QC) samples are discussed and reported. Quality control data review includes but is not limited to detections of organic and inorganic compounds at any concentration in quality control blanks (i.e., trip blanks, equipment rinsate blanks, portable organic-free water system blanks, etc.).

All detections of organic and inorganic compounds will be immediately reported to the FSB QAO. The project leader will analyze of the results to determine if the source of contamination can be identified. If the source of contamination cannot be determined by the project leader, the branch QAO will conduct an additional review of the results to assess the source of contamination. If the source of contamination cannot be determined, the QAO will monitor all quality control results generated by the branch and assess the data for trends of contamination.

If it is determined by the project leader and the FSB QAO that the contamination adversely impacts the data collected during the investigation, the project leader will report the results to their Section Chief and the FQM. The project leader, in consultation with management, will determine whether the impacted data are usable or should be rejected. If data are

rejected, the project leader and their management will determine whether samples must be recollected.

Data reported to the FQM will be analyzed to determine if the contamination is due to non-conforming work. If it is determined by the FQM, in consultation with management, that the contamination is due to non-conforming work, a corrective action is warranted and will be selected and implemented in a timely manner. If a corrective action is required, it must be implemented and reported according to the SESD Operating Procedure for Corrective Action (SESDPROC-009). If contamination is not due to non-conforming field work, then the source of contamination will be identified, if possible, and documented by the FQM. If the source of contamination cannot be determined, FQM will monitor all quality control results generated by SESD and assess the data for trends of contamination.

4.4.1 Quality Assurance Reports

It is each project leader's responsibility to ensure that a copy of the quality assurance data from each field investigation report is provided to the FSB QAO, who will compile a quarterly report of field quality assurance data and forward the report to the FQM.

The FQM will prepare an annual quality assurance report based on the quarterly reports. This report will be distributed to all field investigators each year and will document and discuss all quality control issues or trends identified during the data review. This report will be retained by the FQM to document that QC measures have been taken, that the QC measures are appropriate, that the QC results are acceptable or, if not, that corrective actions were taken.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Field pH Measurement
Effective Date: December 16, 2016 Number: SESDPROC-100-R4
Author
Name: Timothy Simpson
Title: Environmental Scientist
Signature: Inty Sugar Date: 12/14/2016
Approvals
Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick Date: 12/14/16
Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature 12/14/2015

SESD Operating Procedure

Effective Date: December 16, 2016

Page 1 of 9

SESDPROC-100-R4

Field pH Measurement

Field pH Measurement(100)_AF.R4

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-100-R4, Field pH Measurement, replaces	December 16, 2016
SESDPROC-100-R3	
General: Corrected any typographical, grammatical, and/or editorial errors.	
Title Page: Changed the Field Quality Manager from Bobby Lewis to	
Hunter Johnson. Updated cover page to represent SESD reorganization. John Deatrick was not listed as the Chief of the Field Services Branch	
Beautier was not instead as the siner of the Field Sel vices Branch	
SESDPROC-100-R3, Field pH Measurement, replaces	January 29, 2013
SESDPROC-100-R2	
SESDPROC-100-R2, Field pH Measurement, replaces	June 13, 2008
SESDPROC-100-R1	
SESDPROC-100-R1, Field pH Measurement, replaces	November 1, 2007
SESDPROC-100-R0	
SESDPROC-100-R0, Field pH Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	(fe	neral Information	. 4
_	1.1	Purpose	
	1.2	Scope/Application	
	1.3	Documentation/Verification	
	1.4	References	
	1.5	General Precautions	
		.1 Safety	
		.2 Procedural Precautions	
2		ality Control	
3	_	ld pH Measurement Procedures	
	3.1	General	
	3.2	Instrument Calibration	
	3.3	Sample Measurement Procedures	
	3.4	Operational Check	

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field pH measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring the pH of aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain pH measurements of the media being sampled, and that another method must be used to obtain said measurements, the variant instrument and/or measurement procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on SESD's local area network (LAN). The Document Control Coordinator is responsible for ensuring that the most recent version of the procedure is placed on SESD's LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version.

1.5 General Precautions

1.5.1 *Safety*

Proper safety precautions must be observed when conducting field pH measurements. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field pH measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010) and the SESD Operating Procedure for Equipment Inventory and Management, (SESDPROC-108).

Care should be taken not to contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to the manufacturer's specifications.

2 **Quality Control**

All pH meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring* equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

Effective Date: December 16, 2016

3.1 General

pH is defined as the negative logarithm of the effective hydrogen-ion concentration. For routine work, a pH meter accurate and reproducible to within 0.2 Standard Unit (S.U.) is suitable. For NPDES compliance monitoring, the pH meter should be accurate and reproducible to within 0.1 S.U. Both meters should have a range of 0 to 14 S.U.s and be equipped with a temperature-compensation adjustment.

3.2 Instrument Calibration

Many brands of instruments are commercially available for the measurement of pH incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. At a minimum, a two-point calibration should be conducted to ensure the accuracy of the meter. The following are basic guidelines for calibration/verification and are provided as an example:

- 1. Verify the meter's internal temperature sensor (thermistor) against a National Institute of Standards and Technology (NIST) traceable thermometer and note any differences between the thermistor and the NIST-traceable thermometer in the logbook. If the temperatures do not agree within ± 4°C, the unit or probe must be repaired or replaced. Alternatively, if the meter can be used in a manual temperature compensation mode, the NIST-traceable thermometer may be used for temperature readings and the necessary corrections applied. Check and record the temperatures of the standards and the samples.
- 2. If the pH range of the sample is not known, the pH of the sample to be tested should be estimated either from historical data or by using a four-color pH indicator paper or equivalent. Using this information, calibrate the pH meter with the buffers that bracket the expected pH range. Buffer solutions are commonly pH 4, 7 and 10. It may be possible to configure the pH meter so that it can be standardized with buffers other than those in the default configuration.
- 3. Immerse the probe in the first buffer solution and calibrate the meter to read the correct pH. After the initial buffer calibration, calibrate the meter using other buffer solutions, as appropriate. Rinse the probe with deionized water and blot dry or otherwise remove excess rinse water

- between the different buffer solutions. Record the buffer values and temperatures used to calibrate the meter.
- 4. Rinse the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer and read as a sample. If the meter reads within ± 0.2 S.U. of the known value of the buffer (for general applications such as ecological studies) or ± 0.1 S.U. (for regulatory applications such as NPDES or drinking Water programs), record the value indicated by the meter. If the meter is outside of the acceptable accuracy range, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the electrode and/or meter should be replaced.
- 5. Once the meter has been properly calibrated and verified (steps 1-4 above), it is ready for use. Rinse the probe with de-ionized water and store it according to manufacturer's recommendations. Certain instruments may require being left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against a known calibration buffers if used for extended periods (> 4 hrs).
- 6. Unless the manufacturer indicates that the meter maintains its calibration after being turned off, meters must be re-calibrated if they are turned off during their period of use.

3.3 Sample Measurement Procedures

These procedures should be followed when conducting field pH measurements of grab samples:

- 1. Collect a sample. If the meter's thermistor is to be used for the temperature of record for the measurement activity, the temperature should be read as soon as the reading stabilizes and prior to measuring the pH.
 - **Note 1**: When the pH meter response is slow, unstable, or non-reproducible, it may be necessary to check the conductivity. If the conductivity is lower than 20 to 30 µmhos/cm, it is permissible to add 1 ml of 1M potassium chloride solution per 100 ml of sample to improve response time for the probe. Recheck the pH and record.
 - **Note 2**: If the pH measurements are to be used for RCRA regulatory purposes and when the pH approaches the alkaline end (pH

- \geq 11.0) of the scale, the pH measurements should be made by a qualified analyst using laboratory quality equipment to control the sample at 25°C \pm 1°C.
- 2. Immerse the probe in the sample keeping it away from the sides and bottom of the sample container. Allow ample time for the probe to equilibrate with the sample.
- 3. While suspending the probe away from the sides and bottom of the sample container, record the pH.
- 4. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution until the next sample is ready.

These procedures should be followed when conducting in-situ field pH measurements:

- 1. Place the probe into the media to be measured and allow the pH and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.
- 2. When deploying meters for extended periods of time, insure the measurement location is representative of average media conditions.

3.4 Operational Check

Even though it is not necessary to re-calibrate pH meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

1. While in use, periodically check the pH by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer solution. If the measured pH differs by ≥ 0.2 S.U. or 0.1 S.U. (depending on the application) from the buffer solution, the meter must be recalibrated.

A post-operation instrument verification check will be performed using the appropriate buffer(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE		
Title: Field Temperature Me	easurement	
Effective Date: October 23, 2014	Number: SESDPROC-102-R4	
	Authors	
Name: Hunter Johnson Title: Environmental Engineer		
Signature: 1st 2	Date: /0/21/14	
an de	Approvals	
Name: John Deatrick	Local por la resultatilla la	
Title: Chief, Enforcement and Investi	igations Branch	
Signature: Marker &	L Date: 10/22/14	
Name: Laura Ackerman		
Title: Acting Chief, Ecological Asses	sment Branch	
Signature: Hura acke	- Date: 10/21/14	
Name: Hunter Johnson		
Title: Field Quality Manager, Science	e and Ecosystem Support Division	
Signature: 14th	Date: 10/21/14	

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-102-R4, Field Temperature Measurement, replaces SESDPROC-102-R3	October 23, 2014
Cover Page: The Enforcement and Investigations Branch Chief was changed from Archie Lee to John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Laura Ackerman. The FQM was changed from Liza Montalvo to Hunter Johnson.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
Section 2: Omitted the following: "Data Sonde thermistors will be verified on a monthly basis to ensure accuracy. These verification checks are documented in the instrument's tracking logbook."	
SESDPROC-102-R3, Field Temperature Measurement, replaces SESDPROC-102-R2	February 4, 2011
SESDPROC-102-R2, Field Temperature Measurement, Replaces SESDPROC-102-R1	June 13, 2008
SESDPROC-102-R1, Field Temperature Measurement, Replaces SESDPROC-102-R0	November 1, 2007
SESDPROC-102-R0, Field Temperature Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	Ge	neral Information	. 4
	1.1	Purpose	. 4
	1.2	Scope/Application	
	1.3	Documentation/Verification	
	1.4	References	. 4
	1.5	General Precautions	. 5
		1.5.1 Safety	
2		ality Controleld Temperature Measurement Procedures	
	3.1	General	
	3.2	Instrument Verification	
		3.2.1 Field thermometers and thermistors	
		3.2.2 NIST-traceable thermometer	
	3.3	Inspections	. 7
	3.4	Sample measurement procedures for thermometers/thermistors	
	3.5	Units	

Effective Date: October 23, 2014

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when measuring the temperature of aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring the temperature of aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain temperature measurements of the media being sampled, and that another method or measurement instrument must be used to obtain said measurements, the variant instrument and measurement procedure will be documented in the field log book and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). Most Recent Version. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

SESD Operating Procedure Pag

Page 4 of 8 SESDPROC-102-R4

Field Temperature Measurement

Field Temperature Measurement(102)_AF.R4

1.5 General Precautions

1.5.1 *Safety*

Proper safety precautions must be observed when conducting temperature measurements in the field. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The field investigators will address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

2 Quality Control

All thermometers should be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Temperature measurement devices such as pH, conductivity and dissolved oxygen (DO) meter thermistors will be verified against a National Institute of Standards and Technology (NIST)-traceable thermometer before each use as described in Section 3.2.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Temperature Measurement Procedures

3.1 General

Field temperature measurements may be made with a field thermometer, equipment thermistor, or NIST-traceable thermometer. At a minimum, the temperature measurement device should be capable of measuring in 0.1°C increments.

3.2 Instrument Verification

3.2.1 Field thermometers and thermistors

Temperature measurement devices such as field thermometers and equipment thermistors will be verified against a NIST-traceable thermometer prior to use and should agree within ± 4.0 °C. Corrections may be applied for measurements up to ± 4.0 °C depending on investigation objectives, but the instrument must be repaired or replaced beyond that range.

3.2.2 NIST-traceable thermometer

Verification of the NIST-traceable thermometers that are used to verify temperature measuring devices is accomplished by comparing temperature readings from the NIST-traceable thermometer to a thermometer that has an independent certification of accuracy traceable to the National Institute of Standards and Testing. Current certified thermometers are maintained by the SESD Analytical Support Branch and are called reference thermometers.

Each NIST-traceable thermometer is verified by comparing at least annually against a reference thermometer. If corrections need to be applied, they will be noted in the NIST-traceable thermometer. Depending on investigation objectives, project leaders may decide to apply the correction factor as necessary.

3.3 Inspections

All temperature measurement devices should be inspected for leaks, cracks, and/or function prior to each use.

3.4 Sample measurement procedures for thermometers/thermistors

(Make measurements in-situ when possible)

- 1. Clean the probe end with de-ionized water and immerse into sample.
- 2. If not measuring in-situ, swirl the instrument in the sample for mixing and

SESD Operating Procedure

Field Temperature Measurement

Effective Date: October 23, 2014

equilibration.

- 3. Allow the instrument to equilibrate with the sample for at least one minute.
- 4. Suspend the instrument away from the sides and bottom, if not in-situ, to observe the temperature reading.
- 5. Record the reading in the log book. For most applications, report temperature readings to the nearest 0.5°C or to the nearest 0.1°C depending on need.

Note: Always clean the thermometer with de-ionized water or a detergent solution, if appropriate, prior to storage and/or use.

3.5 Units

Degrees Celsius (°C) or Degrees Fahrenheit (°F)

Conversion Formulas:

$$^{\circ}F = (9/5 \, ^{\circ}C) + 32$$
 or $^{\circ}C = 5/9 \, (^{\circ}F - 32)$

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Field Turbidity Measurement		
Effective Date: July 27, 2017	Number: SESDPROC-103-R4	
Au	thors	
Name: Timothy Simpson	A	
Title: Environmental Scientist		
Signature: Justly Sign	Date: 07/25/17	
	provals	
Name: John Deatrick		
Title: Chief, Field Services Branch		
Signature: Oph Dratice	Date: 7/25/17	
Name: Hunter Johnson		
Title: Field Quality Manager, Science and E	cosystem Support Division	
Signature: 1002	Date: 7/25/17	

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-103-R4, <i>Field Turbidity Measurement</i> , replaces SESDPROC-103-R3	July 27, 2017
General: Added to Section 3.6 to include application of various turbidity units and associated methods relative to various applications.	
Title Page: Changed Enforcement and Investigations Branch to the Field Services Branch and changed the Chief from Danny France to John Deatrick. Changed Field Quality Manager from Bobby Lewis to Hunter Johnson.	
Section 1.4: Added new references cited in Section 3.5	
Section 3.2: Added reference to Section 3.5	
Section 3.3.1: Added Table 1 outlining reporting requirements.	
Section 3.5: Introduced different turbidity units associated with various methods and stated importance of using EPA approved methods for regulatory purposes. Also added Figure 1, a decision tree to assist project leaders in selecting the appropriate method to satisfy Data Quality Objectives, and Table 2, outlining technologies, associated units, application, and design.	
SESDPROC-103-R3, <i>Field Turbidity Measurement</i> , replaces SESDPROC-103-R2	January 29, 2013
SESDPROC-103-R2, <i>Field Turbidity Measurement</i> , replaces SESDPROC-103-R1	June 13, 2008
SESDPROC-103-R1, <i>Field Turbidity Measurement</i> , replaces SESDPROC-103-R0	November 1, 2007
SESDPROC-103-R0, Field Turbidity Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	Ger	neral Information	4
	1.1	Purpose	4
	1.2	Scope/Application	
	1.3	Documentation/Verification	4
	1.4	References	4
	1.5	General Precautions	5
	1.5.	1 Safety	5
	1.5.	2 Procedural Precautions	
2	Qu	ality Control	6
3		ld Turbidity Measurement Procedures	
	3.1	General	
	3.2	Instrument Calibration and Verification	
		1 Meter Calibration and Verification	
	3.2.	2 Probe Calibration and Verification	
	3.3	Sample Measurement Procedures	
		1 Grab Sample Measurement	
	3.3.	2 In-Situ Measurement	
	3.4	Operational check	
	3.5	-	
			-
		TABLE OF FIGURES	
Fi	gure 1	: Turbidity Method Decision Tree, adapted from Figure 6.7-2 (USGS 2005) 1	2
		TABLE OF TABLES	
Ta Ta	able 1: able 2:	Reporting Requirements (APHA, 1992)	0
			3

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when conducting field turbidity measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring turbidity of various, aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain turbidity measurements of the media being sampled, and that another method or turbidity measurement instrument must be used to obtain said measurements, the variant instrument and measurement procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

APHA (1992). Turbidity: Method 2130B. Standard Methods for the Examination of Water and Wastewater, 18th Edition, pp. 2-11.

ASTM International (2012). D7315-12 Standard test method for determination of turbidity above 1 turbidity unit in static mode: ASTM International, Annual Book of Standards, Water and Environmental Technology, v. 11.01, West Conshohocken, Pennsylvania.

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

USEPA (1993). Method 180.1: Determination of Turbidity by Nephelometry. Rev. 2.0. Environmental Systems Monitoring Laboratory, Office of Research and Development, Cincinnati, Ohio.

USEPA (2001). Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA.

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

USGS (2004). Office of Water Quality Technical Memorandum 2004.03: Revision of NFM Chapter 6, Section 6.7- Turbidity, available online at: http://water.usgs.gov/admin/memo/QW/qw04.03.html

USGS (2005). National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A6.7, available online at http://pubs.water.usgs.gov/twri9A.

USGS (2012). Turbidity parameter and methods codes, available online at: https://water.usgs.gov/owq/turbidity/Turbidity_parameter_codes_and_methods_codes_(May2012)%20(2).xlsx

1.5 General Precautions

1.5.1 *Safety*

Proper safety precautions must be observed when conducting field turbidity measurements. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field turbidity measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010).

SESD Operating Procedure Field Turbidity Measurement

Effective Date: July 27, 2017

Page 5 of 13

SESDPROC-103-R4

Field Turbidity Measurement(103)_AF.R4

2 Quality Control

All turbidity meters and probes shall be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter or probe is taken to the field, it shall be properly calibrated or verified, according to Sections 3.2 and 3.3 of this procedure, to ensure it is operating properly. These calibration and verification checks shall be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Turbidity Measurement Procedures

3.1 General

Turbidity is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter and microscopic organisms. Many methods are available for the measurement of turbidity including turbidimeters and optical probes. Turbidity is measured by determining the amount of scatter when a light is passed through a sample.

3.2 Instrument Calibration and Verification

Many brands of instruments are commercially available for the measurement of turbidity incorporating a wide variety of technologies (See Section 3.5 for further discussion). The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. Depending on the instrument, the verification and calibration can differ slightly. If the instrument readings do not agree within \pm 10 % of the calibration standards, the unit must be recalibrated, repaired or replaced. The following are basic guidelines for calibration/verification of meters and are provided as an example:

3.2.1 Meter Calibration and Verification

HACH 2100Q Turbidimeter:

Portable turbidimeters are calibrated with Formazin Primary Standards. The manufacturer recommends calibration with a primary standard such as StablCal® Stabilized Standards or with formazin standards every three_months.

Generally only a calibration verification measurement is required in the field; however, if a calibration is needed, record a post calibration reading for each calibration standard used.

Meter Verification:

- 1. Push **Verify Cal** to enter the Verify menu.
- 2. Gently invert the liquid standard several times prior to insertion into meter. Insert the 10.0 NTU (or other defined value) Verification Standard and close the Lid.
- 3. Push **Read**. The display shows "Stabilizing" and then shows the result and tolerance range.

4. Push **Done** to return to the reading display. Repeat the calibration verification if the verification failed. If a meter is unable to pass verification, then that meter will need to be calibrated.

Meter Calibration:

- 1. Push the **CALIBRATION** key to enter the Calibration mode. Follow the instructions on the display. **Note:** Gently invert each standard several times before inserting the standard and use a non-abrasive, lint-free paper or cloth to wipe off the standards.
- 2. Insert the 20 NTU StablCal Standard and close the lid. Push **Read**. The display shows "Stabilizing" and then shows the result. Record the result.
- 3. Repeat Step 2 with the 100 NTU and 800 NTU StablCal Standard. Record both results.
- 4. Push **Done** to review the calibration details.
- 5. Push **Store** to save the results. After a calibration is complete, the meter automatically goes into the Verify Cal mode.

3.2.2 Probe Calibration and Verification

The manufacturer's instruction manual should be consulted for specific procedures regarding probe's calibration, maintenance and use. Their calibration must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. The following are basic guidelines for calibration/verification of probes and are provided as an example:

- 1. Turn the meter "ON" and allow it to stabilize
- 2. Immerse the probe in the first standard solution and calibrate the probe against the solution.
- 3. Rinse the probe with de-ionized water, remove excess rinse water and calibrate the probe using additional standards as appropriate.
- 4. Record the standard values used to calibrate the meter.

3.3 Sample Measurement Procedures

Depending on the meter, the sample measurement procedure can differ slightly.

3.3.1 Grab Sample Measurement

These procedures should be followed when conducting turbidity measurements of grab samples:

- 1. Collect a representative sample and pour off enough to fill the cell to the fill line (about 15 mL) and replace the cap on the cell.
- 2. Gently wipe off excess water and any streaks from surface of sampling vial.
- 3. Turn instrument on. Place the meter on a flat, sturdy surface. Do not hold the instrument while making measurements.
- 4. Insert the sample cell in the instrument so the diamond or orientation mark aligns with the raised orientation mark in the front of the cell compartment. Close the lid.
- 5. If appropriate, select manual or automatic range selection by pressing the range key.
- 6. If appropriate, select signal averaging mode by pressing the Signal Average key. Use signal average mode if the sample causes a noisy signal (display changes constantly).
- 7. Press Read. The display will show ---- NTU. Then the turbidity is displayed in NTU. Record the result to the correct range dependent significant digits as required by EPA Method 180.1 Rev. 2.0 (USEPA, 1993) and SM 2130B (APHA, 1992) (Table 1).
- 8. Rinse the cell with de-ionized water or rinse out with sample water prior to the next reading.

Table 1: Reporting Requirements (APHA, 1992)

Turbidity Range NTU	Report to the Nearest NTU
0–1.0	0.05
1–10	0.1
10-40	1
40-100	5
100-400	10
400-1000	50
>1000	100

3.3.2 In-Situ Measurement

These procedures should be followed when conducting in-situ turbidity measurements:

- 1. Place the probe into the media to be measured and allow the turbidity reading to stabilize. Once the reading has stabilized, record the measurement in the logbook.
- 2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 Operational check

Even though it is not necessary to re-calibrate turbidity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

While in use, periodically check the turbidity by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate calibration standard. If the measured turbidity differs by \pm 10 % (depending on the application) from the calibration standard, the meter must be re-calibrated.

A post-operation instrument verification check will be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

3.5 Units and Application

Due to the availability of various technologies for measuring turbidity, the USGS (United States Geological Survey) in collaboration with ASTM International (American Society for Testing and Materials) has determined that data collected using different methods are not directly comparable and should be reported in units reflecting the specific technology used (USGS 2004; ASTM International 2012) (Table 2).

Measurements taken for regulatory purposes (i.e. National Primary Drinking Water Regulations (NPDWR) monitoring, National Pollution Discharge Elimination System (NPDES) reporting) must be in compliance with EPA approved methods. Approved methods for Clean Water Act programs and Safe Drinking Water Act programs can be found in 40 C.F.R. § 136.3 and 40 C.F.R. § 141.74(a)(1), respectively.

Project leaders should consult the decision tree depicted in Figure 1 to determine the appropriate turbidity method that will meet the project specific Data Quality Objectives. For more detailed information on the different methods and their associated units, refer to the USGS National Field Manual for the Collection of Water-Quality Data, Section 6.7 (USGS 2005) and ASTM designation D7315 (ASTM International 2012). A sensor specific spreadsheet detailing methods and associated units can be found on the USGS Field Manual website under turbidity parameter and methods codes (USGS 2012).

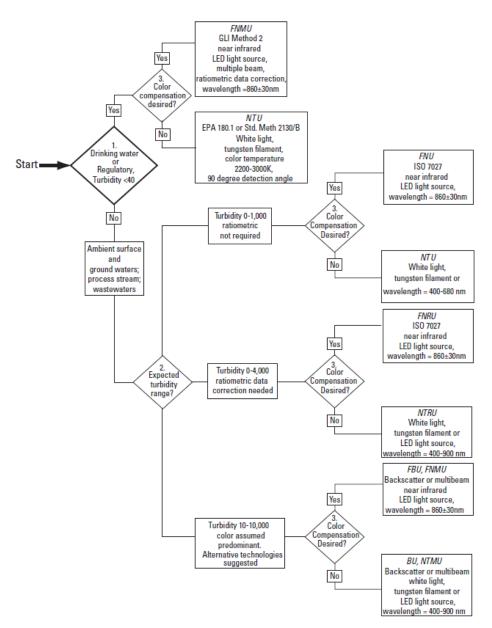


Figure 1: Turbidity Method Decision Tree, adapted from Figure 6.7-2 (USGS 2005)

Table 2: Turbidity Technology, Units, Application, & Design (adapted from ASTM International 2012)

Design and Reporting Unit	Prominent Application	Key Design Features
Nephelometric non-ratio (NTU) Ratio White Light turbidime- ters (NTRU)	White light turbidimeters. Comply with USEPA Method 180.1 for low level turbidity monitoring. Complies with ISWTR regulations and Standard Method 2130B. Can be used for both low and high level measurement.	Detector centered at 90° relative to the incident light beam. Uses a white light spectral source. Used a white light spectral source. Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the
Nephelometric, near-IR turbidimeters, non-ratiometric (FNU)	Complies with ISO 7027. The wavelength is less susceptible to color interferences. Applicable for samples with color and good for low level monitoring.	turbidity reading. Detector centered at 90° relative to the incident light beam. Uses a near-IR (780–900 nm) monochromatic light source.
Nephelometric near-IR turbidimeters, ratio metric (FNRU)	Complies with ISO 7027. Applicable for samples with high levels of color and for monitoring to high turbidity levels.	Uses a near-IR monochromatic light source (780–900 nm). Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the turbidity reading.
Surface Scatter Turbidimeters (NTU)	Turbidity is determined through light scatter from or near the sur- face of a sample.	Detector centered at 90° relative to the incident light beam. Uses a white light spectral source.
Formazin Back Scatter (FBU)	Not applicable for regulatory pur- poses. Best applied to high turbid- ity samples. Backscatter is com- mon with but not all only probe technology and is best applied in higher turbidity samples.	Uses a near-IR monochromatic light source in the 780–900 nm range. Detector geometry is between 90° and 180° relative to the incident light beam.
Backscatter Unit (BU)	Not applicable for regulatory pur- poses. Best applied for samples with high level turbidity.	Uses a white light spectral source (400–680 nm range). Detector geometry is between 90° and 180° relative to the incident light beam.
Formazin attenuation unit (FAU)	May be applicable for some regu- latory purposes. This is commonly applied with spectrophotometers. Best applied for samples with high level turbidity.	Detector is geometrically centered at 0° relative to incident beam (at- tenuation). Wavelength is 780–900 nm.
Light attenuation unit (AU)	Not applicable for some regulatory purposes. This is commonly applied with spectrophotometers.	Detector is geometrically centered at 0° relative to incident beam (at- tenuation). Wavelength is 400-680 nm.
Nephelometric Turbidity Multi- beam Unit (NTMU)	Is applicable to EPA regulatory method GLI Method 2. Applicable to drinking water and wastewater monitoring applications.	Detectors are geometrically cen- tered at 0° and 90°. An instrument algorithm uses a combination of detector readings, which may dif- fer for turbidities varying magni- tude.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Groundwater Level and Well Depth Measurement			
Effective Date: November 3, 2016	Number: SESDPROC-105-R3		
Aut	thors		
Name: Brian Striggow Title: Environmental Engineer			
Signature:	Date: 11/1/16		
Approvals			
Name: John Deatrick			
Title: Chief, Field Services Branch			
Signature: John De Aricle Date: 11/2/16			
Name: Hunter Johnson			
Title: Field Quality Manager, Science and Ecosystem Support Division			
Signature: Date: 11/1/16			

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-105-R3, Groundwater Level and Well Depth Measurement, replaces SESDPROC-105-R2	November 3, 2016
General: Corrected any typographical, grammatical, and/or editorial errors.	
Title Page: Author changed from Tim Simpson to Brian Striggow. Changed the Field Quality Manager from Bobby Lewis to Hunter Johnson. Updated cover page to represent SESD reorganization. John Deatrick was not listed as the Chief of the Field Services Branch	
Section 4: Added section on the Establishment of Well Top of Casing Elevations.	
SESDPROC-105-R2, Groundwater Level and Well Depth Measurement, replaces SESDPROC-105-R1	January 29, 2013
SESDPROC-105-R1, Groundwater Level and Well Depth Measurement, replaces SESDPROC-105-R0	November 1, 2007
SESDPROC-105-R0, Groundwater Level and Well Depth Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	Ge	neral Information	4
	1.1	Purpose	4
	1.2	Scope/Application	
	1.3	Documentation/Verification	4
	1.4	References	4
	1.5	General Precautions	5
	1.5	1 Safety	
		2 Procedural Precautions	
2	Ou	ality Control Issues	6
3	_	ter Level and Depth Measurement Procedures	
	3.1	General	
	3.2	Specific Groundwater Level Measurement Techniques	
	3.3	Special Considerations for Water Level Measurements at Sites with	
		Shallow Groundwater Gradient	8
	3.4	Total Well Depth Measurement Techniques	8
	3.5	Equipment Available	
4	Est	ablishment of Top of Casing Elevations	

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when determining water levels and depths of wells.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators to measure water levels and depths of wells. On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for water level or depth determination, the variant procedure(s) will be documented in the field log book and the subsequent investigation report, along with a description of the circumstances requiring its use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network. The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when measuring water levels in wells and determining their depths. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when measuring water levels and depths of wells:

- Special care must be taken to minimize the risk of cross-contamination between wells when conducting water level and depth measurements. This is accomplished primarily by decontaminating the sounders or other measuring devices between wells, according to SESD Operating Procedure for Field Equipment Cleaning and Decontamination, (SESDPROC-205) and maintaining the sounders in clean environment while in transit between wells.
- Water levels and well depths measured according to these procedures should be recorded in a bound logbook dedicated to the project as per SESD Operating Procedure for Logbooks (SESDPROC-010). Serial numbers, property numbers or other unique identification for the water level indicator or sounder must also be recorded.

2 Quality Control Issues

There are several specific quality control issues pertinent to conducting water level and depth measurements at wells. These are:

- Devices used to measure groundwater levels should be verified annually against a National Institute of Standards and Technology (NIST) traceable measuring tape.. These devices should check to within 0.01 feet per 10 feet of length with an allowable error of 0.03 feet in the first 30 feet. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. All verification and maintenance data should be documented electronically or recorded in a logbook maintained at the Field Equipment Center (FEC) as per the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). The functional check and tape length verification should be performed according to the instructions included in SESDFORM-043, Well Sounder Function Check and Verification, which also includes the form for recording the required information.
- These devices should be decontaminated according to the procedures specified in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) prior to use at the next well.

3 Water Level and Depth Measurement Procedures

3.1 General

The measurement of the groundwater level in a well is frequently conducted in conjunction with ground water sampling to determine the "free" water surface. This potentiometric surface measurement can be used to establish ground water direction and gradients. Groundwater level and well depth measurements are needed to determine the volume of water or drawdown in the well casing for proper purging.

All groundwater level and well depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing and note this procedure in the field log book.

To be useful for establishing groundwater gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. For an isolated group of wells, it is acceptable to use an arbitrary datum common to all wells in that group.

Water levels should be allowed to equilibrate prior to measurement after removing sealing caps. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.

3.2 Specific Groundwater Level Measurement Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods. Method accuracies are noted for each of the specific methods described below.

- Electronic Water Level Indicators These types of instruments consist of a spool of dual conductor wire, a probe attached to the end and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or audible buzzer attached to the spool will signal contact. Penlight or 9-volt batteries are normally used as a power source. Measurements should be made and recorded to the nearest 0.01 foot.
- Other Methods There are other types of water level indicators and recorders available on the market, such as weighted steel tape, chalked tape, sliding float method, air line pressure method and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the

measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot should not be used.

3.3 Special Considerations for Water Level Measurements at Sites with Shallow Groundwater Gradient

Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps and the same sounder should be used for all measurements, if possible. The sounding activity should be coordinated to allow all wells to be sounded within the minimum possible time. This is particularly important in areas with potential tidal influences.

3.4 Total Well Depth Measurement Techniques

The well sounder, weighted tape or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well and sediment in the bottom of the well can also make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements. The operator may find it easier to allow the weight to touch bottom and then detect the 'tug' on the tape while lifting the weight off the well bottom. All total depth measurements must be made and recorded to the nearest 0.1 foot. As a cautionary note, when measuring well depths with the electronic water level indicators, the person performing the measurement must measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth. This is necessary because the tape distance markings are referenced to the electrodes, rather than the end of the probe. For electronic sounders maintained at the SESD FEC, the sounder reel will be marked with the appropriate additional length identified as the 'TD adder'.

3.5 Equipment Available

The following equipment is available for ground water level and total depth measurements:

- Weighted steel measuring tapes
- Electronic water level indicators

4 Establishment of Top of Casing Elevations

To establish groundwater surface elevations, the measured distance from the top of casing to the water surface is subtracted from the well top of casing (TOC) elevation. Obtaining accurate TOC elevations is crucial to developing an accurate groundwater surface elevation map and determination of groundwater flow direction.

The only acceptable means of surveying well TOC elevations is differential leveling conducted to third order standards. Third order differential leveling has allowable error defined by the following formula:

Allowable Error
$$(ft) = 0.05 \times \sqrt{Survey loop length (miles)}$$

This work must be conducted with an auto level as the leveling instrument. Surveying TOC elevations with a total station or survey-grade GPS will not provide the requisite accuracy.

When adding wells to a monitoring network, it is permissible to tie the new well elevations to the known TOC elevations of existing wells in the network. The elevations of several wells in the existing network should be checked to assure that the relative differences in elevation match the recorded elevation data.

Generally, the ground surface elevations at each well should be surveyed at the same time.

Region 4

U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Field Measurement of Dissolved Oxygen		
Effective Date: April 12, 2017 Number: SESDPROC-106-R4		
A	Author	
Name: Nathan Barlet		
Title: Environmental Engineer		
Signature: Mate My Date: April 5 2017		
Approvals		
Name: John Deatrick		
Title: Chief, Field Services Branch		
Signature: John Deatrick Date: 4/11/17		
Name: Hunter Johnson		
Title: Field Quality Manager, Science and Ecosystem Support Division		
Signature: Part Date: 4/11/17		

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-106-R4, Field Measurement of Dissolved Oxygen, replaces SESDPROC-106-R3	April 12, 2017
General: Corrected any typographical, grammatical, and/or editorial errors. In addition, any references to former Division organizational structure was updated to reflect current structure.	
Title Page: Changed the Author from Hunter Johnson to Nathan Barlet. Changed the Field Quality Manager from Bobby Lewis to Hunter Johnson. Updated cover page to represent SESD reorganization.	
Table of Contents: Added Sections 3.2.1 Water-Saturated Air Method, 3.2.2 Air-Saturated Water Method, and 3.2.3 Zero-DO Verification & 2-Point Calibration. Changed Section 3.5 from "Operational Check" to "Operational Verification." Updated page numbers.	
Section 1.4: Added the citations for Benson and Krause (1980), Benson and Krause (1984), USGS (2013 <i>a</i>), and USGS (2013 <i>b</i>) as references,	
Section 3.1: Changed "volume of oxygen contained in a volume of water" to "mass of molecular oxygen contained in a volume of water." Changed "pressure" in first paragraph and third bullet point to "atmospheric pressure."	
Section 3.2: Added "However, some optical DO meters are capable of a two-point calibration at 0% and 100% saturation, refer to Section 3.2.3 for applicability."	
Added Section 3.2.1 Water-Saturated Air Method, which includes information on the calibration procedure for the water-saturated air method. Added "Allow at least 10-15 minutes for the temperature and dissolved oxygen readings to equilibrate. Ensure that water droplets are removed from the luminescence cap or Clark cell membrane and thermistor before calibration. Refer to Section 3.5 for calibration verification procedure."	
Added Section 3.2.2 Air-Saturated Water Method, which includes information on the calibration procedure for the air-saturated water	

method. Added "Refer to Section 3.5 for calibration verification procedure."

Added Section 3.2.3 Zero-DO Verification & 2-Point Calibration. Added "It is recommended that a zero-DO verification is conducted periodically or when concentrations are expected to be below 1 mg/l (USGS, 2013a). A zero-DO solution can be prepared by dissolving 1 gram of sodium sulfite in 1 liter of deionized water. This should be made fresh weekly or as needed. If the unit is equipped with a wiper, it should be removed before immersing in zero-DO solution. The reading should not exceed a concentration of 0.2 mg/l dissolved oxygen in the zero-DO solution. For Clark cells that exceed this concentration. replace the electrolyte and membrane before repeating the zero-DO verification process. For optical probes that read above 0.2 mg/l in zero-DO solution, replace the sensor cap if it is expired or perform a 2point calibration if applicable. Some optical DO probes are capable of 2-point calibrations using a zero-DO solution and the air-saturated water method discussed in Section 3.2.2. Refer to the manufacturer's instruction manual for the appropriate 2-point calibration procedure. Ensure that the probe is thoroughly rinsed of zero-DO solution after verification or calibration to avoid measurement interferences caused by residual sodium sulfite."

Section 3.4: Changed the fifth bullet point to read "The DO meter should be capable of auto-correcting for specific conductivity/salinity or a separate instrument should be used to measure specific conductivity/salinity so that the final DO measurement(s) can be corrected."

Section 3.5: Changed the title from "Operational Check" to "Operational Verification."

Changed first paragraph to read "A post-calibration and post-operation instrument verification check should be performed using one of the techniques described in Sections 3.2.1 and 3.2.2 or 3.2.3 (for 2-point calibrations) to quantify potential instrument drift during use. A verification check will be performed after a calibration and at the end of all measurements"

Changed second paragraph to read "It may be appropriate to verify the calibration of a DO meter periodically during the course of a day's measurements when conducting individual measurements. A DO probe may be re-calibrated throughout the day if drift is occurring. The verification DO concentration should be measured and recorded in the field logbook prior to any instrument adjustment." Also added the sentence "For long-term deployments a post-operation verification should be performed at the end of the deployment."

Added third paragraph which reads "Verification is done by comparing a post-calibration or post-operation reading at 100% saturation conditions to a DO solubility table value at the ambient air/water

temperature and barometric pressure. Post-calibration and post-operation readings should not exceed a maximum of \pm 0.2 mg/l from the DO solubility table value. DO solubility tables can be accessed via the U.S. Geological Survey's DOTABLES software (USGS, 2013 <i>b</i>) which are based on equations from Benson and Krause (1980; 1984)."	
SESDPROC-106-R3, Field Measurement of Dissolved Oxygen, replaces SESDPROC-106-R2	January 8, 2014
SESDPROC-106-R2, Field Measurement of Dissolved Oxygen, replaces SESDPROC-106-R1	February 12, 2010
SESDPROC-106-R1, Field Measurement of Dissolved Oxygen, replaces SESDPROC-106-R0	November 1, 2007
SESDPROC-106-R0, Field Measurement of Dissolved Oxygen, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	General Information	6
1.1	Purpose	6
1.2	Scope/Application	
1.3	Documentation/Verification	
1.4	References	6
1.5	General Precautions	
1.	.5.1 Safety	7
2	Quality Control	8
3	Field Measurement of Dissolved Oxygen	9
3.1	General	
3.	.1.1 Clark Cell Probes	<i>9</i>
3.	.1.2 Luminescent Probes	<i>9</i>
3.2	Calibration	10
3.	.2.1 Water-Saturated Air Method	10
3.	.2.2 Air-Saturated Water Method	10
3.	.2.3 Zero-DO Verification and 2-Point Calibration	11
3.3	Maintenance	
3.4	Conducting Field Measurement of Dissolved Oxygen	
3.5	Operational Verification	

1 General Information

1.1 Purpose

This document describes methods and considerations to be used and observed when conducting field measurements of dissolved oxygen in surface water, treated wastewater and in gas media for specific applications (e.g., reaeration measurement).

1.2 Scope/Application

On the occasion that SESD field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of dissolved oxygen, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Benson, B.B., and Krause, D., Jr, 1980. The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere—1. Oxygen: Limnology and Oceanography, v. 25, no. 4, p. 662–671.

Benson, B.B., and Krause, D., Jr, 1984. The concentration and isotopic fractionation of oxygen dissolved in freshwater and seawater in equilibrium with the atmosphere: Limnology and Oceanography, v. 29, no. 3, p. 620–632.

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Field Branches Quality Management Plan, SESDPLAN-001, Most Recent Version

SESD Operating Procedure

Page 6 of 12

SESDPROC-106-R4

Field Measurement of Dissolved Oxygen

Field DO Measurement(106)_AF.R4

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

USGS, 2013a. Dissolved Oxygen (ver. 3.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, sec. 6.2, http://water.usgs.gov/owq/FieldManual/Chapter6/6.2_v3.0.pdf.

USGS, 2013b. DOTABLES (ver. 3.5): Dissolved Oxygen Solubility Tables, https://water.usgs.gov/software/DOTABLES/.

1.5 General Precautions

1.5.1 *Safety*

Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

Appropriate precautions should be observed when working in and around bodies of water and on boats. Be aware of fast flowing waters, waterway obstructions such as dams, and other vessels on the water.

2 Quality Control

All dissolved oxygen meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter is utilized in the field, it will be calibrated and verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

For in-situ measurements, an instrument warm-up period appropriate for that instrument should be provided. Consult manufacturer's documentation for appropriate warm-up time.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

Following instrument use, an end check should be performed using one of the techniques described in Section 3.2 to quantify potential instrument drift during use.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Measurement of Dissolved Oxygen

3.1 General

Dissolved oxygen can be defined as the mass of molecular oxygen contained in a volume of water. The solubility of oxygen in water is dependent on the water temperature, salinity and atmospheric pressure.

- As the temperature of the water decreases, the solubility of oxygen increases.
- As salinity increases, the solubility of oxygen decreases.
- As atmospheric pressure decreases (altitude increases), the solubility of oxygen decreases.

Several methods for measurement of dissolved oxygen in water are available utilizing a variety of technologies. When measuring dissolved oxygen for compliance with the National Pollutant Discharge Elimination System (NPDES) Program, only approved methods will be used. Approved methods can be found in the Code of Federal Regulations (CFR) 40 CFR Part 136.

3.1.1 Clark Cell Probes

Clark cell probes utilize an oxygen permeable membrane that covers an electrolytic cell which consists of a cathode and an anode. The anode acts as a reference electrode. After passing through the permeable membrane, the oxygen is reduced by an applied potential voltage that is referenced to the anode. The reduction current at the cathode is directly proportional to the partial pressure of oxygen in liquid, expressed as %-air saturation. The concentration of oxygen, in mg/l, is calculated based on the %-air saturation reading and the solubility of oxygen in water at the sample temperature.

In general, sample collection using a DO probe requires only lowering the probe into the sample media and recording or logging the results. The probe should be lowered gently to prevent damage to the membrane and gently turned when initially lowered to remove any attached air bubbles. If the instrument requires the use of a stirrer, the stirrer should be turned on before recording any readings. Prior to use, the instrument should be calibrated and any manufacturer specified warm-up period should be observed.

3.1.2 Luminescent Probes

Luminescent dissolved oxygen probes employ a light emitting diode (LED) to provide incident light, which excites the oxygen-sensitive luminescent-dye

SESD Operating Procedure

Page 9 of 12

SESDPROC-106-R4

Field Measurement of Dissolved Oxygen

Field DO Measurement(106)_AF.R4

molecule substrate of the sensor. After dissipation of the excitation energy, longer-wavelength light is emitted (luminescence). The magnitude of steady-state luminescence (intensity) is measured by the sensor and is inversely proportional to the dissolved oxygen concentration.

Sample collection with this type of probe should follow the sample procedures described in the second paragraph of Section 3.1.2 for Clark Cell probes.

3.2 Calibration

Many brands of instruments are commercially available for *in-situ* measurement of dissolved oxygen using Clark cell probes and luminescent probes. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate.

In general, calibrations should be conducted at temperatures and pressures as close as possible to those of the sample media for the most accurate measurements. Due to the sensitivity of dissolved oxygen measurements to changes in temperature, the temperature probe or thermistor should be verified using a NIST traceable thermometer prior to each calibration. Most dissolved oxygen meters utilize a one-point calibration which is generally performed using either water-saturated air or air-saturated water. However, some optical DO meters are capable of a two-point calibration at 0% and 100% saturation, refer to Section 3.2.3 for applicability.

3.2.1 Water-Saturated Air Method

When using the water-saturated air method, the probes should be placed in a 100% relative humidity environment open to ambient air temperature and barometric pressure. Allow at least 10-15 minutes for the temperature and dissolved oxygen readings to equilibrate. Ensure that water droplets are removed from the luminescence cap or Clark cell membrane and thermistor before calibration. Refer to Section 3.5 for calibration verification procedure.

3.2.2 Air-Saturated Water Method

When using air-saturated water for calibration, an aeration device such as an aquarium pump with a diffusion stone should be placed in a vessel containing tap water. The water in the vessel should be aerated for a minimum of one hour at a

SESD Operating Procedure

Page 10 of 12

SESDPROC-106-R4

Field Measurement of Dissolved Oxygen

Field DO Measurement(106)_AF.R4

constant temperature. Saturation should be verified by placing the dissolved oxygen probe in the vessel and monitoring the temperature and dissolved oxygen readings for stabilization. Avoid placing the probe in the direct stream of air bubbles. Bubbles can accumulate on the probe surface and cause erroneous readings. Refer to Section 3.5 for calibration verification procedure.

3.2.3 Zero-DO Verification and 2-Point Calibration

It is recommended that a zero-DO verification is conducted periodically or when concentrations are expected to be below 1 mg/l (USGS, 2013a). A zero-DO solution can be prepared by dissolving 1 gram of sodium sulfite in 1 liter of deionized water. This should be made fresh weekly or as needed. If the unit is equipped with a wiper, it should be removed before immersing in zero-DO solution. The reading should not exceed a concentration of 0.2 mg/l dissolved oxygen in the zero-DO solution. For Clark cells that exceed this concentration, replace the electrolyte and membrane before repeating the zero-DO verification process. For optical probes that read above 0.2 mg/l in zero-DO solution, replace the sensor cap if it is expired or perform a 2-point calibration if applicable. Some optical DO probes are capable of 2-point calibrations using a zero-DO solution and the air-saturated water method discussed in Section 3.2.2. Refer to the manufacturer's instruction manual for the appropriate 2-point calibration procedure. Ensure that the probe is thoroughly rinsed of zero-DO solution after verification or calibration to avoid measurement interferences caused by residual sodium sulfite.

3.3 Maintenance

Maintenance procedures vary depending on the technology utilized by each instrument and the manufacturer. The manufacturer's instruction manual should be consulted for instrument specific procedures. Following are some general guidelines for maintaining dissolved oxygen meters:

- Inspect probes for damage prior to use.
- For Clark cell probes, membranes and electrolyte solution should be changed prior to each study, when feasible.
- Battery voltages should be checked. For meters that will be deployed unattended, new or fully charged batteries should be used for each study.
- All calibration and maintenance procedures performed should be thoroughly documented.

Effective Date: April 12, 2017

3.4 Conducting Field Measurement of Dissolved Oxygen

Following are guidelines for conducting field measurements of dissolved oxygen:

- Except as described in specific operating procedures, dissolved oxygen measurements should if possible be conducted *in-situ*.
- When measuring DO at distinct points in the water column, the probe should be allowed to equilibrate at each location prior to recording the measurement.
- In water bodies with a great deal of flow, a weight may be attached to the probe guard or support cable to insure the probe is maintained at the proper depth.
- Insure that the measurement location is representative of conditions within the water body or reach. Avoid measurements directly below turbulent sections or still water unless these conditions represent most of the water body or reach.
- The DO meter should be capable of auto-correcting for specific conductivity/salinity or a separate instrument should be used to measure specific conductivity/salinity so that the final DO measurement(s) can be corrected.

3.5 Operational Verification

A post-calibration and post-operation instrument verification check should be performed using one of the techniques described in Sections 3.2.1 and 3.2.2 or 3.2.3 (for 2-point calibrations) to quantify potential instrument drift during use. A verification check will be performed after a calibration and at the end of all measurements.

It may be appropriate to verify the calibration of a DO meter periodically during the course of a day's measurements when conducting individual measurements. A DO probe may be re-calibrated throughout the day if drift is occurring. The verification DO concentration should be measured and recorded in the field logbook prior to any instrument adjustment. For long-term deployments a post-operation verification should be performed at the end of the deployment.

Verification is done by comparing a post-calibration or post-operation reading at 100% saturation conditions to a DO solubility table value at the ambient air/water temperature and barometric pressure. Post-calibration and post-operation readings should not exceed a maximum of \pm 0.2 mg/l from the DO solubility table value. DO solubility tables can be accessed via the U.S. Geological Survey's DOTABLES software (USGS, 2013*b*) which are based on equations from Benson and Krause (1980; 1984).

SESD Operating Procedure

Page 12 of 12

SESDPROC-106-R4

Field Measurement of Dissolved Oxygen

Field DO Measurement(106)_AF.R4

Region 4

U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

OLEKATING	TROCEDURE
Title: Equipment Inventory and N	/lanagement
Effective Date: August 13, 2015	Number: SESDPROC-108-R5
Au	uthor
Name: Tim Simpson Title: Environmental Scientist Signature: Im Important Scientist	Date: 08/12/2015
Арр	provals
Name: John Deatrick Title: Chief, Field Services Branch Signature: John Deatrick	Date: 8/12/15
Name: Hunter Johnson Title: Field Quality Manager, Science and	

Effective Date: August 13, 2015

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-108-R5, <i>Equipment Inventory and Management</i> , replaces SESDPROC-108-R4.	August 13, 2015
Cover Page: Changes made to reflect reorganization of SESD from two field branches to one: John Deatrick listed as the Chief, Field Services Branch. The FQM was changed from Bobby Lewis to Hunter Johnson.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
Section 2.2.2: The following language was added: "Before being placed into service, field equipment must be verified by a qualified individual. The verification process can be conducted by first calibrating the equipment, then checking the equipment against a known standard. Personnel may also choose to compare measurement values of the new equipment to currently utilized equipment to further document the verification. Once completed, the verification documentation must be provided to the BFEM to be stored with the equipment records."	
SESDPROC-108-R4, <i>Equipment Inventory and Management</i> , replaces SESDPROC-108-R3.	February 6, 2013
SESDPROC-108-R3, <i>Equipment Inventory and Management</i> , replaces SESDPROC-108-R2.	April 6, 2009
SESDPROC-108-R2, Equipment Inventory and Management, replaces SESDPROC-108-R1.	October 19, 2007
SESDPROC-108-R1, <i>Equipment Inventory and Management</i> , replaces SESDPROC-108-R0.	October 1, 2007
SESDPROC-108-R0, Equipment and Supply Management, Original Issue.	May 4, 2007

TABLE OF CONTENTS

1	Gen	neral Information	4
	1.1	Purpose	4
	1.2	Scope/Application	4
	1.3	Documentation/Verification	4
	1.4	Definitions	4
	<i>1.4.</i> .	1 Calibration	4
	1.4.	2 Calibration Verification	5
	<i>1.4.</i> .	3 Preventative Maintenance	5
	1.4.	4 Branch Field Equipment Manager	5
	<i>1.4.</i> .	5 Qualified Individual	5
	1.4.	6 Equipment Log	5
	<i>1.4.</i>	7 SESD Field Equipment Tracking System	5
	1.5	Precautions	5
	1.6	References	6
2	Met	thodology	7
	2.1	General	7
	2.2	Equipment Purchase and Receipt	8
	2.2.	1 Purchasing Equipment	8
	2.2.	2 Receiving Equipment	8
	2.3	Equipment Inventory	9
	2.3.	1 Inventory	9
	2.3.	2 Equipment Labeling and Marking	9
	2.4	Equipment Maintenance 1	0
	<i>2.4.</i> .	1 Documentation1	.0
	2.4.	2 Repair and Re-certification for Use 1	.0
	<i>2.4.</i> .	3 Required Maintenance 1	.1
	2.4.	4 Record Keeping 1	.1
	2.5	Equipment Calibration 1	.1
	2.5.		
	2.5.		
	2.5	1 • 1 • • • • • • • • • • • • • • • • • • •	
	2.6	Records	
	2.7	Equipment Sign-out/Sign-in 1	4

Effective Date: August 13, 2015

Contents

1 General Information

1.1 Purpose

This document describes the procedures necessary to demonstrate the operational status and inventory of equipment used for field measurement activities and equipment that comes into direct contact with the sample media and has the potential to cross contaminate samples between sampling stations.

1.2 Scope/Application

This procedure covers the approaches and documentation used for the purchase, maintenance, calibration, verification and inventory of equipment used for direct field measurement activities. This procedure includes the maintenance and use of microscopes, volumetric equipment and equipment that may come into direct contact with the sample media (i.e. submersible pumps) and has the potential to cross contaminate samples between sampling stations. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 Definitions

1.4.1 Calibration

The set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system and corresponding known values. The results of a calibration permit the estimation of errors associated with the measurement equipment.

Effective Date: August 13, 2015

1.4.2 Calibration Verification

Provides a means of determining that deviations between measured values and known values are within the limits of error defined during calibration. The results provide an indication that the instrument/system is working properly.

1.4.3 Preventative Maintenance

A program of routine actions such as cleaning, lubrication, adjusting, or testing to keep equipment ready for use. The most important effect of a preventative maintenance program is to ensure measurement system reliability.

1.4.4 Branch Field Equipment Manager

Staff, designated by management, who are responsible for ensuring that the procedures for Equipment Inventory and Management are followed.

1.4.5 Qualified Individual

Individual who has received on the job training and has experience working with specific measurement instruments.

1.4.6 Equipment Log

Notebook, log book or electronic file that contains a copy of the purchase order, if available, as well as, maintenance, calibration, verification records, performance checks, correction factors and sign-out/sign-in records. Equipment logs will be established for all equipment used for field measurement activities or equipment that comes into direct contact with the sample media and has the potential to cross contaminate samples between sampling stations. The development of equipment logs is the responsibility of the Branch Field Equipment Managers.

1.4.7 SESD Field Equipment Tracking System

Electronic database used to sign-out/sign-in sampling equipment, track equipment use history, and maintain equipment availability status.

1.5 Precautions

To ensure the safe and reliable operation of equipment, the manufacturers' directions for transport, cleaning, decontamination, storage, maintenance and operation of equipment will be followed. When possible, a copy of the instruction manual will be provided with sampling equipment to be taken in the field. In addition, field activities will be conducted

in accordance to the SESD Safety, Health and Environmental Management Program (SHEMP).

Handling of contaminated equipment is addressed under the following operating procedures: Field Equipment Cleaning and Decontamination at the Field Equipment Center (SESDPROC-206) and Field Equipment Cleaning and Decontamination (SESDPROC-205).

1.6 References

American National Standard ANSI/ASQC M1-1996, Calibration Systems

American National Standard ANSI/NCLS Z2540-1-1994, Calibration Laboratories, and Measuring and Test Equipment - General Requirements

SESD Safety, Health and Environmental Management Program (SHEMP) Manual, most recent version.

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, most recent version.

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, most recent version.

SESD Operating Procedure for Competency and Proficiency Testing, SESDPROC-006, most recent version.

SESD Operating Procedure for Purchasing of Services and Supplies, SESDPROC-015, most recent version.

SESD Operating Procedure for Control of Nonconforming Work, SESDPROC-019, most recent version.

FEC Loan-In Form, SESDFORM-011, most recent version.

Analytical Support Branch Standard Operating Procedure for the Certification of Laboratory Thermometers, SOP ASB 100G.

Effective Date: August 13, 2015

2 Methodology

2.1 General

Equipment (hardware and related software) used for field measurement activities and equipment that comes into direct contact with the sample media and has the potential to cross contaminate samples between sampling stations will meet quality requirements identified for each piece of equipment. Important factors in establishing quality requirements include the parameters to be measured and the sensitivity and specificity of the detection system used. Quality requirements must include ensuring that equipment is ready for use. Specifically:

- 1. SESD will have adequate equipment to conduct measurement activities.
- 2. Equipment used for field measurement activities will be capable of achieving the accuracy and precision required by the measurement objectives.
- 3. When SESD is required to use environmental data collection equipment outside its permanent control, it will ensure that all relevant SESD criteria in this procedure are met.
- 4. Field measurement equipment used by SESD will be secured at all times, as feasible, based on field conditions.
- 5. Operating instructions and/or manuals from the manufacturer will be available for each piece of equipment, when possible.
- 6. Field investigators will only operate equipment for procedures which they are authorized per SESDPROC-006 to perform.
- 7. Equipment used for field measurements will be handled, transported, shipped, stored and operated in a manner that prevents damage, gross contamination and deterioration. Equipment will be handled and maintained in accordance to the manufacturer's operating instructions. Decontamination of equipment will be in accordance to procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) and Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

Effective Date: August 13, 2015

2.2 Equipment Purchase and Receipt

2.2.1 Purchasing Equipment

Equipment covered in this procedure is purchased using procurement requests (PR) or purchase card orders and can be initiated by the BFEM or designee. The initiator of a purchase is responsible for preparing a PR or purchase card order that specifies the correct name of the item, the relevant quality criteria of the item, the item number, a quote or price, possible sources and any other associated information that helps identify the correct item to be purchased. The sources identified must be capable of providing the equipment according to the defined specifications. A copy of the purchase order or purchase card order will be maintained in the equipment log. Once the order has been prepared, the information is forwarded to the appropriate BFEM for origination of the purchase and management will authorize and sign the order and forward it to the purchasing official. The purchasing official will ensure the order is processed according to the information on the PR or purchase card order.

2.2.2 Receiving Equipment

Anyone can accept delivery of equipment orders. For equipment purchases received at the SESD laboratory, the BFEM or initiator of the purchase will inspect the items to ensure they comply with the PR or purchase card order. If the items are acceptable, the BFEM or initiator will sign and date the invoice that accompanied the order and any other required documentation and forward it to the purchasing official. The purchasing official will maintain a file of all SESD purchases.

For purchases received at the Field Equipment Center, contract personnel will inspect the items to ensure they comply with the PR or purchase card order. If the items are acceptable, the contract personnel will sign and date the invoice that accompanied the order and any other required documentation and forward it to the appropriate BFEM. The original paperwork (signed invoice) will be forwarded to the purchasing official.

Before being placed into service, field equipment must be verified by a qualified individual. The verification process can be conducted by first calibrating the equipment, then checking the equipment against a known standard. Personnel may also choose to compare measurement values of the new equipment to currently utilized equipment to further document the verification. Once completed, the verification documentation must be provided to the BFEM to be stored with the equipment records.

If any equipment is found to be unsuitable for use, the BFEMs will document the problems and any action taken to correct that problem. The documentation will

include a description of the item, the deficiency and the vendor. The BFEM will also compile all occurrences of unsuitable consumables, supplies or services and determine what further corrective action may be necessary and notify the Field Quality Manager if deemed necessary.

2.3 Equipment Inventory

2.3.1 Inventory

The BFEMs are responsible for maintaining a current equipment inventory list for their specific areas. The BFEMs will maintain a central, comprehensive list of all field measurement and sampling equipment subject to this procedure. Field measurement equipment, including sampling equipment that comes into contact with the sample media and has the potential to cross contaminate samples between stations (i.e., submersible pumps and vacuum chambers), will be included in this inventory. The equipment inventory list for each instrument or piece of equipment will include:

- 1. A description of the property and software, if applicable (e.g., pH meter, dissolved oxygen meter, etc.).
- 2. Manufacturer or vendor name
- 3. Model number
- 4. Serial number or other manufacturer identification number
- 5. A unique identifier, known as the SESD ID Number. These identifiers will be assigned by the BFEM.
- 6. Storage location (e.g., Field Equipment Center, SESD Laboratory)
- 7. Date received and/or date placed in service, where available.
- 8. Status of the equipment (e.g., surplus, damaged, etc.)
- 9. A reference to the manufacturer's instruction manual title.

2.3.2 Equipment Labeling and Marking

Prior to being placed into the equipment inventory, all equipment covered under this procedure will be inventoried and labeled with a unique SESD identification number. The identification number will be assigned only to the identified equipment and will not be reused if the meter is excised or disposed. Equipment that is no longer used or cannot be repaired will be removed from the inventory.

Equipment received after the effective date of this procedure will be assigned a number that includes the date the equipment was received followed by a sequential number starting at 01 (e.g., 031407-01, 031407-02, etc.). BFEMS will ensure that duplicate SESD ID Numbers are not assigned to equipment.

Equipment received before the effective date of this operating procedure will be assigned a number that will incorporate all or part of the serial number or other manufacturer number as the unique SESD ID number.

2.4 Equipment Maintenance

Maintenance will consist of preventative care and corrective repair. Both approaches should be used to keep equipment in working order. Each item of field measurement equipment will be checked by a qualified individual prior to use. Critical spare parts, which cannot be easily obtained while in the field, will be sent out with the equipment during field investigations.

Equipment maintenance will include software upgrades for certain instruments. SESD management will assign staff to serve as a point of contact for equipment, such as GPS or Sondes that may require periodic software upgrades in order to collect field measurements. The point of contact will ensure that software upgrades are conducted on all equipment. The point of contacts will maintain a list of the equipment which will include the serial number, SESD ID Number, software version, software upgrade dates and the storage location of the equipment. The point of contact will provide the information to the appropriate BFEM to be included in the equipment inventory.

2.4.1 Documentation

The BFEMs are responsible for the development of equipment logs. Maintenance, calibration and verification requirements for equipment will be documented in the SESD Field Equipment Tracking System or equipment log.

2.4.2 Repair and Re-certification for Use

Equipment known or suspected to be defective will be taken out of service and clearly labeled, preferably with a red tag, until it has been repaired and shown by calibration, verification or testing to function properly. When equipment is tagged in the field as defective, the SESD project leader will notify the appropriate BFEM in writing, either by email or by using a load-in form (SESDFORM-011), that equipment requires repair.

For equipment maintained at the FEC which is routinely handled and maintained by contract personnel, the BFEM will be responsible for having the equipment repaired. Once repaired, the BFEM will notify the FEC contract personnel that the equipment has been returned. The contract personnel will ensure that the equipment is functioning properly prior to it being used for field investigations. The BFEMs are responsible for placing all documentation associated with the equipment repair in the SESD Field Equipment Tracking System or appropriate

maintenance section of the equipment log. This documentation includes written notifications regarding the equipment repair and any information provided from the manufacturer which describes the defect and the repair.

For equipment stored at the SESD laboratory, or stored at the FEC and not routinely handled and maintained by contract personnel, the BFEM or a designated qualified individual will be responsible for having the equipment repaired. Once repaired, the BFEM or qualified individual will ensure the equipment is functioning properly prior to it being used for field investigations. The BFEM or qualified individual is responsible for placing all documentation associated with the repair of equipment stored at the SESD laboratory in the SESD Field Equipment Tracking System or appropriate maintenance section of the equipment log. This documentation includes the written notifications regarding the equipment repair and any information provided which describes the defect and the repair.

If there is the potential that data collected with defective equipment were adversely impacted, the BFEM will notify the appropriate Branch Quality Assurance Officer (QAO). The QAO will notify affected management and The Field Quality Manager and the issue will be handled according to the SESD Operating Procedure for Control of Nonconforming Work (SESDPROC-019).

2.4.3 Required Maintenance

The BFEMs are responsible for ensuring that equipment maintenance is performed in-house or by an outside service.

2.4.4 Record Keeping

Records of all maintenance, service, repairs and histories of any damage, malfunction or modification of field measurement equipment will be maintained in the equipment logs. The record will describe hardware and software changes and/or updates and show the dates when these occurred.

2.5 Equipment Calibration

Prior to being used in the field, measurement equipment will be visually inspected and a calibration, calibration verification or performance check will be conducted to ensure it is in working condition. A post-operation instrument verification check will be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. When practicable, equipment requiring calibration will be labeled to indicate the status of calibration and the date when recalibration is due. Calibration acceptance criteria based on data quality objectives will be established on a case by case basis for each field study. Project Leaders will be responsible

for ensuring the acceptance criteria are met. Calibration and measurement requirements are found in individual measurement procedures.

When equipment or reference standards are calibrated by an outside calibration service, SESD will ensure the vendor is ISO 17025 accredited or has some other equivalent means for demonstrating competence, measurement capability and traceability.

All reasonable measures will be taken to safeguard equipment from adjustments which would invalidate the measurements following calibration of the equipment. Field investigators will handle, transport and store equipment in accordance to manufacturer recommendations. Periodic calibration or performance checks will be conducted during field investigations to ensure that equipment calibration has not been adversely impacted between measurement locations.

For equipment that is not directly used for field measurement, visual examination, safety checks or, if appropriate, performance checks, will be conducted by the FEC contract personnel or the project leader to ensure the working condition of the equipment. Microscopes, including attachments, will be cleaned and serviced as needed prior to use.

Volumetric equipment will be maintained by visual examination and cleaning at the Field Equipment Center. Performance checks will be conducted by the FEC contract personnel or the project leader prior to initial use and at intervals depending on the frequency of use.

2.5.1 Documentation

Records for equipment that is sent off-site for calibration recertification will be maintained in the equipment log books. All calibrations or calibration verifications performed at the SESD laboratory or Field Equipment Center will be recorded in the SESD Field Equipment Tracking System or appropriate equipment log.

All calibrations or calibration verifications performed in the field will be recorded in the project specific logbook(s) by the individual conducting the calibration or verification and stored in the associated project file. Calibration of equipment conducted by SESD field investigators and other qualified personnel will be conducted in accordance with the manufacturer's recommendations

When calibrations require correction factors, the correction factors will be documented in instrument operating procedures, equipment logs and written methods (field logbooks).

2.5.2 Traceability, Certification, and Verification Records

The program for the calibration or calibration verification of equipment must ensure that, where the concept is applicable, all significant measurements are traceable through certificates of calibration held by SESD, and/or to National Standards of Measurement. National Institute of Standards and Technology (NIST) traceable standards will be used, if available. For equipment maintained at the FEC and sent off-site for calibration, certificates or other records of calibration will be maintained in a central file at the FEC. Additionally, NIST traceable documentation for buffers, standards, calibration gases or reference materials will be maintained in a central file at the FEC.

For equipment maintained at the SESD laboratory and sent off-site for calibration certificates or other records of calibration will be maintained in the lab where the equipment is stored. Additionally, NIST traceable documentation for buffers, standards, calibration gases or reference materials will be maintained in a central file at the SESD laboratory with the equipment.

SESD will maintain records of actions taken to verify the quality of equipment whose properties could affect the quality of sampling, measurement and related activities. Examples would be thermometer, calibration standard or buffer verification. Thermometers used during field investigations will be verified by the SESD Analytical Support Branch (ASB) or EPA contract personnel utilizing the ASB Standard Operating Procedure for the Certification of Laboratory Thermometers, SOP ASB 100G. The SESD ASB is accredited by the National Environmental Laboratory Accreditation Conference.

Critical reference materials such as reagents and consumable materials that affect the quality of tests and/or calibrations will be verified according to the procedures described in the SESD Operating Procedure for Purchasing Services and Supplies, SESDPROC-015.

2.5.3 Equipment Performance Checks

New equipment will be calibrated or verified by qualified personnel to verify that it is adequate to perform its intended function, and calibrated before release for use in the field. Records of calibration or verification will be maintained in the equipment log books. If any equipment proves to be unsuitable for use, the BFEMs will document the issue, notify the purchasing official and return the deficient equipment to the vendor.

If equipment leaves the direct control of SESD for a period of time, the BFEMs will ensure that the function and, where necessary, the calibration status of the equipment is checked and shown to be satisfactory before the equipment is returned to service.

2.6 Records

The BFEMs are responsible for maintaining a current equipment inventory list for their specific programs. The FQM will maintain a central, comprehensive list of all field measurement and sampling equipment subject to this procedure.

The BFEMs are responsible for creating equipment logs for all equipment in their specific program used for field measurement activities. Additionally, they are responsible for auditing and maintaining equipment maintenance, calibration and verification records in the equipment logs. These records must be made available to SESD personnel prior to their use for field measurement.

These records will include:

- 1. A copy of the Purchase Order, if available, or other record showing item received and date placed into service
- 2. Acceptance inspection record of the equipment (copy of signed invoice)
- 3. Maintenance, calibration and verification logs (including software if applicable)
- 4. Identification of individuals accessing maintenance, calibration and verification logs
- 5. Calibration certificates for manufacturers calibrations (if applicable)
- 6. Fundamental calibration or any other performance checks information
- 7. Calibration verification record (showing standards/reference materials used)
- 8. Calibration correction factors, if applicable
- 9. Records of handling, transportation and storage of equipment
- 10. Complaint log (if applicable)
- 11. A record of the most recent version of firmware or software for the equipment.

2.7 Equipment Sign-out/Sign-in

All measurement equipment will be signed-out prior to use in the field and signed-in following use in the field. This will be done using the SESD Field Equipment Tracking System or by using an equipment sign-out/sign-in form. Each form is specific to the type of measuring equipment being checked out and includes calibration or verification data, as well as, project name and project leader information.

FEC contract personnel will primarily be responsible for equipment sign-out and sign-in at the FEC. However, in their absence, it is the project leader's responsibility to sign out the measurement equipment. For measurement equipment that is not routinely handled or maintained by contract personnel or equipment stored at the SESD laboratory, the project leader or field investigator using the equipment is responsible for checking the equipment out and in.

Each equipment log will contain an equipment sign-out/sign-in form. Equipment defects or damage that is identified while in the field should be noted on the FEC Load-In Form (SESD FORM-011) when the equipment is signed in.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Global Positioning System	
Effective Date: June 23, 2015	Number: SESDPROC-110-R4
Aut	hors
Name: Jonathan Vail Title: Environmental Scientist, Regional Signature:	Expert Date: 6 18 2015
Name: Mel Parsons Title: Life Scientist Signature:	Date: 6/18/15
Name: Brian Striggow Title: Environmental Engineer Signature:	Date: 6/18/15
Аррг	rovals
Name: John Deatrick Title: Chief, Field Services Branch Signature: Man Drattick	Date: 6/18/15
Name: Hunter Johnson Title: Field Quality Manager, Science and Signature:	

SESD Operating Procedure

Page 1 of 21

SESDPROC-110-R4

Global Positioning System

Global Positioning System(110)_AF.R4

Effective Date: June 23, 2015

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-110-R4, Global Positioning System, replaces SESDPROC-110-R3	June 23, 2015
Cover Page: SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Liza Montalvo to Hunter Johnson.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
Section 2.1.1 : Changes were added to elaborate on the description and purpose of GPS systems.	
Section 2.1.3 : Changes made to reflect the abilities of different differential GPS systems. Sentence added to reflect the preferences to certain differential GPS systems.	
Section 2.2.1 : Added to explain that the GPS measurement estimate will be based on a certain number of standard deviations.	
Section 2.2.2: Changes were made to reflect a name change.	
Section 2.4.1: Changes were made to reflect the current procedures.	
Section 2.4.2 : Changes were added to reflect the changes in current procedure practices. Conversion process removed and revised in a later section.	
Section 4.X : Conversion procedure updated and revised to reflect the current practices. Paragraph added to reflect the standard format for navigational purposes.	
Section 2.5 : Removed the DOP where it includes accuracy requirements for what the output should include to reflect the changes in the operating procedures	

SESDPROC-110-R3, Global Positioning System, replaces SESDPROC-110-R2	April 20, 2011
SESDPROC-110-R2, Global Positioning System, replaces SESDPROC-110-R01	November 1, 2007
SESDPROC-110-R1, Global Positioning System, replaces SESDPROC-110-R0	October 1, 2007
SESDPROC-110-R0, Global Positioning System, Original Issue	March 22, 2007

TABLE OF CONTENTS

1	Gen	eral Information	.5
	1.1	Purpose	5
	1.2	Scope/Application	5
	1.3	Documentation/Verification	5
	1.4	References	6
2	Met	hodology	.7
	2.1	General	
	2.1.	GPS Description	7
	2.1.2	2 GPS Accuracy Factors	8
	2.1.3	B Differential GPS	9
	2.2 Re	quirements for Locational Information1	0
	2.2.	Data Uses1	0
	2.2.2	2 Datums and Data formats 1	2
	2.3	Quality Control Procedures	3
	2.4	Special Considerations	3
	2.4.	Special considerations for the use of Trimble® Geo7X Mapping Grade	
		Receivers1	3
	2.4.2	2 Special considerations for the use of Garmin® and other General-Use	
		Grade Receivers 1	8
	2.4.3	3 Coordinate Conversion 1	8
	2.5	Records	20

Contents

1 General Information

1.1 Purpose

This document describes the Global Positioning System (GPS) and procedures, methods and considerations to be used and observed when using GPS to record location data in the field. Guidance is provided on accuracy requirements for various uses of location data and potential means to obtain the requisite accuracy. This document contains direction developed solely to provide internal guidance to SESD employees.

1.2 Scope/Application

The procedures contained in this document are to be used by SESD field investigators when using the Global Positioning System to obtain the geographical coordinates of sampling locations and/or measurements during field investigations. In SESD investigations, GPS is the preferred means of collecting horizontal location information. In most cases the accuracy of GPS is unsuitable for collection of elevation data.

On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain the required coordinate information and alternate procedures are employed, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. GPS users must be currently qualified as proficient in the operation of the specific GPS equipment to be used. The manufacturer's operation manuals should be used for detailed information on the use of specific GPS equipment. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

SESD Operating Procedure Global Positioning System

Page 5 of 21

SESDPROC-110-R4

Global Positioning System(110)_AF.R4

1.4 References

Rand Corporation, <u>The Global Positioning System, Assessing National Policies, Appendix B, GPS History, Chronology, and Budgets</u>, 1995.

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version.

Trimble® Navigation Limited, Mapping Systems General Reference, Revision B, 1996.

USEPA, <u>Global Position Systems – Technical Implementation Guidance</u>, Office of Environmental Information (EPA/250/R-03/001), 2003.

USEPA, GIS Technical Memorandum 3. <u>Global Positioning Systems – Technology and It's Application in Environmental Programs</u>, Research and Development (PM-225). EPA/600/R-92/036, 1992.

USEPA, <u>Locational Data Policy</u>, Office of Information Resources Management, IRM Policy Manual 2100 Chapter 13, 1991.

2 Methodology

2.1 General

2.1.1 GPS Description

The Navigation Satellite Time and Ranging (NAVSTAR) Global Positioning System (GPS) is a worldwide radio-navigation system created by the U. S. Department of Defense (DOD) to provide navigation, location, and timing information for military operations. System testing using a limited number of satellites began in 1978 with the system being declared fully operational in 1995. The system was declared available for civilian uses in the 1980s and has seen burgeoning civilian application for navigation and mapping. GPS is the U.S. implementation of a Global Navigation Satellite System (GNSS). Increasingly, GPS receivers have the capability to utilize signals from other GNSS such as the Russian GLONASS or European Galileo systems. SESD has no limitations on the use of signals from other GNSS.

The GPS system consists of three basic elements: the space segment, control segment, and user segment. The space segment consists of the constellation of up to 24 active NAVSTAR satellites in six orbital tracks. The satellites are not in geo-synchronous orbit and are in constant motion relative to a ground user. The control segment consists of several ground stations that serve as uplinks to the satellites and that make adjustments to satellite orbits and clocks when necessary. The user segment consists of the GPS receiver which will typically consist of an antenna, multi-channel receiver, and processing unit.

For the purposes of this document, the user segment GPS receivers may be loosely grouped into Recreational and Navigational receivers (henceforth referred to as General-Use receivers), Mapping Grade receivers, and Survey Grade receivers.

- Most General-Use grade receivers are available on the retail market to consumers for a variety of applications including boating, hiking, and automotive navigation. They display an instantaneous reading of position and are generally not optimized for data collection. Waypoints containing instantaneous position fixes can often be stored and downloaded. The accuracy of these receivers is adequate for many environmental applications.
- Mapping Grade receivers are used for applications such as resource management and Geographical Information System (GIS) feature collection. The receivers are capable of averaging multiple position fixes for greater accuracy and then datalogging the results with sufficient information to post-correct the positions as described below. The accuracy that can be achieved may be better than one meter.

• Survey Grade receivers can provide accuracy at the centimeter level by using long occupation times and special techniques for receiver use and data processing. Survey Grade receivers are not currently used by SESD in field investigations.

GPS receivers derive positions by simultaneously measuring the distance (range) to several satellites in precisely known orbits, and using trilateration of the ranges to calculate a unique position for the receiver. The range to each satellite is determined by precisely measuring the transit time of radio signals broadcast from the satellites.

2.1.2 GPS Accuracy Factors

The accuracy of the basic GPS system is approximately 15m. GPS accuracy can be affected by a number of factors including the Selective Availability feature, atmospheric delays, satellite clock and orbit errors, multipath signals, signal strength, and satellite geometry relative to the user.

In the early GPS implementation, the DOD used a feature known as Selective Availability (SA) to degrade the quality and subsequent accuracy of the GPS signals to non-DOD users. With Selective Availability enabled, accuracy of position fixes could be as poor as 100m without the use of differential correction techniques described below. Currently there is no SA limitation in accuracy in place with a stated Executive Branch intention to not return to the use of the SA signal degradation.

As satellites move in their orbits and some signals are blocked by obstructions, the geometry of the available satellite signals relative to the user will constantly change. When the satellites with available signals are clustered closely together in the sky, small errors in range will result in large errors in reported position. Conversely, when the satellites are distributed more broadly across the sky, the resultant position errors will be at their minimum. The general measure of this phenomenon is Dilution of Precision (DOP), which may be represented as Position Dilution of Precision (PDOP), or more specifically for geographical coordinate collection, Horizontal Dilution of Precision (HDOP). Mapping and Survey Grade receivers generally can calculate and display DOP and allow the user to limit logging to times when the higher potential accuracy conditions of low DOP prevail. General-Use receivers may display DOP and use DOP with other factors to estimate a general accuracy figure. DOP may range from approximately 2 to 50, with high quality work usually requiring a HDOP of less than 4-6.

Signal strength and multipath signals relate to the strength and quality of the signal reaching the receiver antenna. Signal attenuation by the atmosphere, buildings, and tree cover limit the accuracy of the ranges obtained. The measure of signal strength is Signal to Noise Ratio (SNR), generally measured in decibels (db). Most receivers of any grade will display the SNR of the satellite signals in a bar graph or table. Mapping Grade

SESD Operating Procedure
Global Positioning System

Page 8 of 21

SESDPROC-110-R4

Global Positioning System(110)_AF.R4

Receivers generally allow the user to specify a minimum signal strength for the use of a satellite signal (commonly 2-15db). Poor signal strength can be resolved by waiting for satellite locations to change or moving the receiver location. Multipath signals result from portions of the satellite signal bouncing off terrain, structures, or atmospheric disturbances, resulting in a degraded total signal. Higher quality Mapping Grade receivers may be capable of rejecting the stray multipath signals, such as Trimble® receivers using EverestTM technology.

2.1.3 Differential GPS

Selective Availability, clock errors, and orbital errors affect all GPS users, and atmospheric delays affect all users over a relatively wide region. A second GPS receiver in the same general area as the user will experience the same errors from these sources as the user's receiver. Consequently, correction factors from a remote station at a known location can be applied to the user's receiver in a process known as Differential GPS (DGPS). DGPS can be applied in real-time using additional radio signals, or after the collection event by a method called post-correction.

Real-time DGPS uses established networks of base stations at precisely surveyed locations. The US Coast Guard operates a system of 80 base stations which became fully operational in 1999. The range corrections are broadcast on marine radiobeacon frequencies, with redundant coverage of most of the US coastline and the Mississippi River. There is near complete single beacon coverage of most of the internal US, but there are known gaps in coverage in both EPA Region 4 and the US as a whole. The system is sometimes referred to using the more general term DGPS or in nomenclature referring to the beacon-based nature of the system. Beacon-based DGPS is implemented primarily in Navigational and Mapping Grade receivers. Use of beacon based DGPS at SESD has become increasingly rare in favor of use of the Wide Area Augmentation System

Real-time DGPS can also be implemented with a Space Based Augmentation System (SBAS). The most common SBAS used in the United States is the Wide Area Augmentation System (WAAS), developed by the Federal Aviation Administration to meet the additional demands on GPS for aircraft navigation. The WAAS network of base stations collects information on satellite clock errors, orbital errors, and atmospheric conditions. The error information is transferred to satellites in geo-synchronous orbits and subsequently broadcast to suitably equipped GPS receivers on frequencies compatible with the GPS range signals. While the beacon-based DGPS passes specific satellite range corrections to the receivers, WAAS communicates a model for the errors which is usable over large areas. Current Mapping Grade receivers will likely use WAAS with or without the option of beacon-based DGPS. Modern General-Use receivers are generally equipped with WAAS differential correction capability.

Post-Corrected DGPS is accomplished by downloading the receiver survey files to a desktop or laptop computer and then retrieving correction files for the same time period

SESD Operating Procedure

Page 9 of 21

SESDPROC-110-R4

Global Positioning System

Global Positioning System(110)_AF.R4

(generally via the internet) from an established base station in the area of the survey. Post-processed accuracy improves with proximity of the base station to the surveyed locations and base station data should be used from a station within 300km of the site surveyed. The survey positions are processed by application software and a new set of positions is generated using the correction data. The capability for post-processed differential correction is limited to Mapping Grade and Survey Grade receivers.

Various factors limit GPS accuracy in the vertical plane to approximately half of that obtainable in the horizontal plane, i.e., if a location fix is accurate to 3 m in the horizontal plane, it may only be accurate to 6 m in the vertical plane. Since relatively high accuracy is usually required for the uses of elevation data, GPS is rarely used to obtain and report elevations.

2.2 Requirements for Locational Information

2.2.1 Data Uses

Locational information can serve many purposes in an environmental investigation, a few of which are listed below:

- 1. Providing an unambiguous means to identify facilities or sampling plats.
- 2. Providing locational information to key analytical data in a GIS based data archiving system to the original sampling locations.
- 3. Differentiating watersheds.
- 4. Providing information to calculate extents and volumes of contamination.
- 5. Providing a means to relocate the media represented by samples for removal or treatment.
- 6. Providing information to prepare presentation graphics of sampling locations.

Depending on the specific uses for the data and the type of work being performed, there will be different needs for the accuracy of the locational data. Studies where a sample represents a large area of relatively homogeneous material would not require the same accuracy as the location of a permanent monitoring well. Below are broad guidelines for the accuracy that might be required for different applications.

Desired Accuracy	Application	
100 m	Open ocean work where sample is presumed to be representative of a large area	
20 m	Open water work (lakes or estuaries) where sample is presumed to be representative of a large area	
10 m	Stream and river work where samples are presumed to be broadly representative of a reach	
5-3 m	Stream work where samples are representative of a specific narrowly defined section	
10 m	Air Monitoring Stations	
10 - 3 m	Microscale air monitoring	
3 - 1 m	Permanent monitoring wells	
1 m	Locations of 'Hot Spots' destined for removal of limited areal extent	
3 - 1 m	Locations of Temporary groundwater wells in plumes requiring narrow delineation	
3 m	Locations of Temporary groundwater wells in broad plumes	
3 m	m Locations of environmental samples with sample spacing >20 m	
5 m	5 m Locations of environmental samples with sample spacing >60 m	
200 - 20 m	m Coordinates describing a facility where mobile waste units are sampled	
30 - 3 m	Locations of industrial process areas or NPDES permitted facilities where the sampling locations are described in field notes relative to the process or site features	

Specific demands of a study may drive increased or decreased requirements for accuracy. The preferred means of locational data collection for most studies will be GPS, although alternate means are permissible if they meet accuracy requirements. The following table indicates the accuracy that may be expected from various means of establishing coordinates.

Accuracy	Description	
200 - 50 m	Map Derived, coarse work	
40 - 20 m	Map Derived, fine work or using GIS with digital imagery	
15 m	General-UseGeneral-Use Grade GPS, w/o WAAS	
5 m	General-Use Grade GPS, w/ WAAS or beacon corrections	
10 m	Mapping Grade GPS, no corrections, averaged readings,	
3 m	Mapping Grade GPS w/ differential correction, averaged readings	
1 m	Mapping Grade GPS w/ differential correction, controlled DOP and SNR, averaged readings	
<10 cm	Surveying Grade GPS or optical surveying (dependent on baseline length)	

Accuracy is a term used to describe the degree of conformity of a measurement. In GPS, accuracy is usually specified as an estimate of the radius from the measured coordinates that is likely to include the actual coordinates. The estimate will be based on a percentage likelihood or a certain number of standard deviations that the accuracy estimate is met. As such, it is recognized that some measurements will fall outside of the specified accuracy. For the purposes of SESD GPS work, the nominal accuracy figures derived from manufacturer's literature for specific operating conditions, displayed by the receiver at the time of feature collection, or output from processing software will be taken at face value.

2.2.2 Datums and Data formats

In general, a datum is a reference from which other measurements are taken. In the development of surveying systems by civil entities, different datums were used as base references that will result in differing coordinates for the same location. A GPS receiver will generally display coordinates in a number of different user-selected datums. Unless there are specific requirements on a project, all SESD work should be conducted using the WGS84 datum. Alternatively, the nearly equivalent NAD83 datum may be used if WGS84 is unavailable as a receiver option. If an alternate coordinate system is used where coordinates are obtained and recorded in field logbooks, the use of the alternate coordinate system should also be noted in the logbook.

The Region 4 Equis database requires that coordinates for sample locations be entered in the WGS84 datum and dd.dddddd format. Unless specific project requirements dictate otherwise, all coordinates explicitly stated in reports will be in WGS84 format and in all cases the datum used will be specified.

There is no SESD policy on significant digits for GPS information, and accuracy should not be implied from the presence of significant digits in reported coordinates. However, good scientific practice should be followed in the presentation of locational information in order that useful information not be truncated or a higher degree of accuracy implied. The following table shows the incremental distance in latitude represented by the least significant digit for various coordinate formats:

dd.dddddo°	Approximately 4" or 10 cm
dd.ddddd°	Approximately 44" or 1.1 m
dd.dddd°	Approximately 36' or 11 m
dd°mm'ss"	Approximately 100' or 30 m
dd°mm'ss.x"	Approximately 10' or 3 m
dd°mm'ss.xx"	Approximately 1' or 30 cm
dd°mm.xxxx'	Approximately 7" or 18 cm
dd°mm.xxx'	Approximately 6' or 1.8 m
dd°mm.xx'	Approximately 60' or 18 m

2.3 Quality Control Procedures

By nature of its origin in the DOD and recent application to aircraft navigation, the GPS is designed for high reliability. GPS failures resulting in an incorrect reading beyond the bounds of known errors are so rare that the possibility can be ignored for most SESD studies. If a study requires the verification of receiver function, this can be accomplished by verifying that a receiver displays the correct position while occupying a known benchmark.

2.4 Special Considerations

The data quality objectives for the application, availability of receivers, and other factors will dictate the type of receiver used. There are several specific considerations for the use of the various GPS receivers available at SESD.

2.4.1 Special considerations for the use of Trimble® Geo7X Mapping Grade Receivers

Several important settings can be adjusted or checked under the 'Setup' toolbar.

SESD Operating Procedure
Global Positioning System

Page 13 of 21

SESDPROC-110-R4

Global Positioning System(110)_AF.R4

Effective Date: June 23, 2015

Suggested settingsfor Trimble® Geo7X receivers are:

1. Settings>Coordinate System:

System = Latitude/Longituude

Datum = WGS 1984

Altitude Reference = MSL

Altitude Units – Feet

These settings would rarely need to be changed, but should be checked prior to collecting data.

2. Settings>Real-time Settings

Set to:

Choice 1 = Integrated SBAS

Choice 2 =Wait for Real-time

When 'Choice 2' is set to 'Wait for Real-time', the receiver will not log positions if a WAAS signal cannot be received. When this occurs, 'Choice 2' may need to be changed temporarily to 'Use uncorrected GNSS'. The location would then be logged with the reduced accuracy of uncorrected GPS, which should be noted in field logbooks. The accuracy of the position can be improved later by post-processing.

3. Settings>Logging Settings

At the top of the logging settings dialog is the 'Accuracy Settings' label. Tap the 'wrench' box to the right of the first field to open the Accuracy Settings dialog box.

Set the first box under 'Accuracy Value for Display/Logging' to 'Horizontal'

The box below the Horizontal/Vertical selection chooses whether positions will be corrected in real time or by post-processing. Choose 'In the field' if Real-time WAAS corrections will be used, or 'Postprocessed' if positions will be post-corrected. This selection will affect the accuracy estimates displayed. If Real-time correction is used when this setting is set to 'Postprocessed', the estimated error reported will be erroneously low.

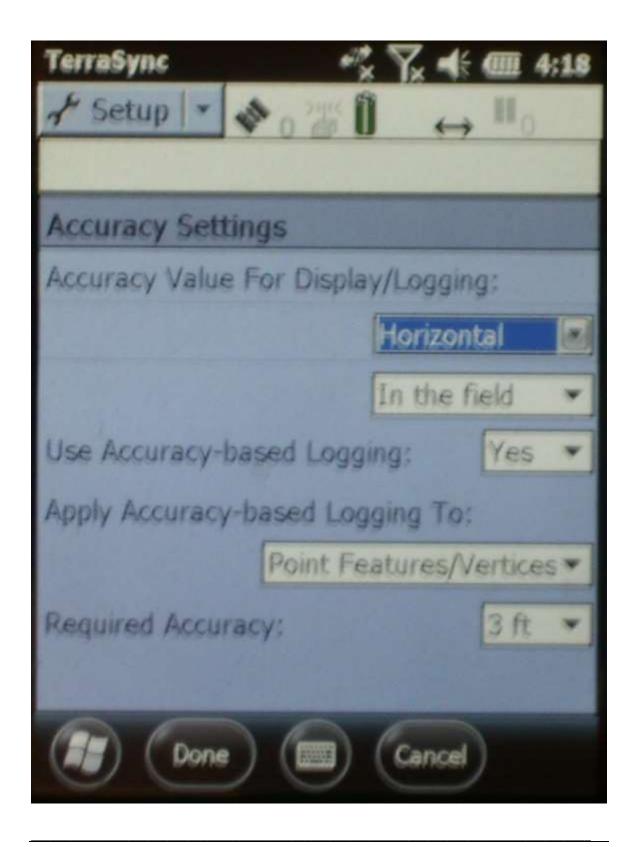
Select 'Yes' or 'No' for accuracy based logging. Selecting 'Yes' will prevent the receiver from logging until the desired accuracy can be achieved. This setting is recommended when a specific accuracy for locational data is required. Selecting 'Yes' enables the following choices:

The next box, 'Apply Accuracy-based Logging to:' can be set to point features or 'All Features'. Set appropriately.

The 'Required Accuracy' field selects the accuracy threshold that will allow logging. If a position cannot be logged because the threshold cannot be met, several options are available:

- 1. Set the accuracy threshold to a higher but still acceptable value.
- 2. Plan to post-correct the coordinates and change the settings in this dialogs accordingly. Post-correction will generally allow more accurate correction than WAAS.
- 3. Return to the point at a later time when propagation or satellite geometry is more suitable.
- 4. Use the 'Offset' feature (see below) to log the positions from a more suitable location (e.g. less tree cover).

The screen shot below shows the Accuracy Settings Dialog Box:



SESD Operating Procedure
Global Positioning System

Page 16 of 21

SESDPROC-110-R4

Global Positioning System(110)_AF.R4

If the point to be logged cannot be occupied, or signals cannot be received at the location, the 'Offset' feature of the receiver can be used. The SESD Geo7X receivers can employ a laser rangefinder and internal compass to calculate the offsets. To use the 'Offset' feature:

- 1. Begin logging from the offset location.
- 2. Pull down the 'Options' menu and select 'Offset', then 'Distance Bearing'
- 3. The Offset dialog will open where distances and bearings could be manually entered.
- 4. To use the laser rangefinder and compass to populate the dialog fields, press the physical ' $\oplus \Box$ button located on the receiver below the screen.
- 5. The laser rangefinder application will start and a red sighting laser will turn on. Point the laser at the desired point to survey and sight the object in the crosshairs on the screen. When sighted on the survey object, tap on the '⊕' icon on the screen to lock in the distance and bearing at the bottom of the screen. Press the '⊕' icon again to update the readings, or press the '✓□ icon to transfer the bearing and distance to the Offset dialog box.
- 6. If the numbers transferred to the Offset dialog box are appropriate, tap 'Done' to return to the feature logging screen.

There is no quality system calibration performed on the electronic compass and rangefinder. It is the responsibility of the user to assure that the bearings and ranges returned by the laser rangefinder system will result in accuracy consistent with the overall GPS work. A quick check for reasonableness can be performed by comparing the logged position on the Map screen with the current position shown.

Photos can also be taken with the unit and associated with the logged features. The user is referred to vendor documentation for instruction in the use of this feature.

Trimble® receivers at SESD contain a data dictionary that can facilitate the management of GIS data. If the COC_GIS dictionary is selected at the time of file creation, SESD standard media codes can be assigned to features at the time of logging that will accompany the data through the download process. The use of the COC_GIS data dictionary can simplify the management of the data when processed in a GIS system or when submitted to the Equis data archiving system.

The logging interval of the Trimble® Geo 7X receivers can be set to a 1 or 5 second interval as an option during feature collection. The setting may be set to 1 second to expedite feature collection. A point feature should have a minimum of 36 positions logged to obtain the additional accuracy afforded by the averaging of

Effective Date: June 23, 2015

positions. After a minimum of 36 positions are logged and the feature is closed, the averaged coordinates for the location can be obtained by selecting the feature on the 'Map' screen. The averaged position should always be the one entered into field notebooks.

2.4.2 Special considerations for the use of Garmin® and other General-Use Grade Receivers

Several types of General-Use grade of receivers are in use at SESD, most from the Garmin® product line. Most of the Garmin® receivers operate with a similar interface to facilitate use of the various devices. The nautical receivers/depth sounders are suitable for recording location data within the limitations described for the General-Use grade receivers.

Some receivers will allow averaging of positions to improve accuracy. Use of this feature is recommended when possible.

Anecdotal experience at SESD suggests that GPS designed primarily for automobile navigation is unsuitable for obtaining locational data.

The older Garmin receivers would display on the status screen whether differential correction was in use by displaying small 'D' characters at the base of the signal strength bars. Newer receivers do not display this information directly and correction status can only be ascertained by the accuracy estimates or monitoring the status screen for acquisition of signals from the WAAS satellites.

2.4.3 Coordinate Conversion

Coordinates may be displayed in different formats on the various receivers, or coordinates obtained from outside SESD may be presented in a format other than that required. If the coordinates are in the correct datum, but recorded in the dd°mm'ss.sss" format they can be arithmetically converted to dd.dddddd format. Convert to decimal degrees as follows:

Converting to decimal degrees (dd.ddddd) from degrees°minutes'seconds" (dd°mm'ss.sss"):

dd.ddddd = dd + (mm/60) + (ss.sss/3600)

Example: Convert 33°28'45.241" to decimal degrees

$$33 + (28/60) + (45.241/3600) = 33.479236$$

The reverse conversion is accomplished as follows:

Converting to degrees minutes' seconds" from decimal degrees

Starting with dd.dddddd

Multiply .dddddd by 60 to obtain mm.mmmm

Multiply .mmmm by 60 to obtain ss.sss

Then dd°mm'ss.sss" = dd & mm & ss.sss

Example: Convert 33.479236 to dd°mm'ss.sss" format

Multiply .479236 by 60 to obtain 28.7540 (mm.mmmm)

Multiply .7540 by 60 to obtain 45.241 (ss.sss)

Dd°mm'ss.sss" = 33° & 28' & 45.241" = 33°28'45.241"

The standard format for navigational purposes is decimal minutes (dd°mm.mmm'). This format is utilized due to the fact that nautical navigation charts are set up in this format. However, location information must be converted to a decimal degree (dd.dddd°) format in order for GIS software to properly interpret the information and for submission to the Region 4 Equis database. Assuming the coordinates have been recorded in the proper datum, the conversion can be accomplished by dividing the minutes portion of the coordinates by 60.

Converting to decimal degrees from decimal minutes:

 $dd.ddddd^{\circ} = dd + (mm.mmm/60)$

Example: Convert 81°49.386' to decimal degrees

81 + (49.386/60) = 81.8231 degrees

The reverse conversion is accomplished as follows:

 $dd^{\circ}mm.mmm' = dd & (.ddddd*60)$

Example: Convert 81.8231 degrees to decimal minutes (dd°mm.mmm')

Multiply .8231 by 60 to obtain 49.386 (mm.mmm)

81° & 49.386' = 81°49.386'

GPS users need to familiarize themselves with the differences between the formats, as they can appear similar. Spreadsheets can automate the conversion process.

2.5 Records

The GPS coordinates and the SESD equipment identification number of the GPS receiver should be recorded in field logbooks at the time of GPS coordinate collection. The data logging capability of receivers may be used in lieu of the requirement to record the coordinates in logbooks when the following conditions can be met:

- 1. The location can easily be found later if it needs to be resurveyed prior to demobilization. A permanent monitoring well can easily be resurveyed, while most open-water work would not afford this opportunity.
- 2. The data is downloaded and ascertained to meet the accuracy requirements for the project prior to demobilization from the site.
- 3. The data is stored in at least two separate locations for transport, such as a laptop hard drive and a flash drive or compact disc.

In all cases where positions are electronically recorded, the provisions of the Electronic Records section of the SESD Operating Procedure for Control of Records (SESDPROC-002) should be followed.

Where locational data is collected and processed electronically, but not reported explicitly in the final report, a copy of the coordinates in text format should be output and entered into the project file in paper or electronic form. The output should include:

- 1. Latitude, generally in dd.ddddd format.
- 2. Longitude, generally in dd.ddddd format.
- 3. Date of collection.

- 4. A note on the differential correction process used where it supports the accuracy requirements.
- 5. The datum used for the export.

Trimble® Pathfinder Office can create files with this information when exporting coordinates to a text file. The information will be contained in the .pos and .inf files.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE		
Title: In Situ Water Quality Monito	ring	
Effective Date: July 19, 2013	Number: SESDPROC-111-R3	
Aut	hors	
· · · · · · · · · · · · · · · · · · ·		
	· · · · · · · · · · · · · · · · · · ·	
Name: Mel Parsons		
Title: Life Scientist Signature: Description Descripti	ate 7/11/13	
Аррі	rovals	
Name: John Deatrick		
Title: Chief, Ecological Assessment Branch		
	ate: 7/15/13	
Name: Bobby Lewis		
Title: Field Quality Manager, Science and Eco	system Support Division	
Signature: MUSE.	vate: 7/15/13	

Effective Date: July 19, 2013

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-111-R3, <i>In Situ Water Quality Monitoring</i> , replaces SESDPROC-111-R2	July 19, 2013
General: Corrected any typographical, grammatical, and/or editorial errors.	
Cover Page: Omitted John Deatrick as an author. Changed the Ecological Assessment Branch Chief from Bill Cosgrove to John Deatrick. Changed the FQM from Laura Ackerman to Bobby Lewis.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
Section 1.2: Added the following statement – "Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use."	
Section 1.4.2: Replaced "instrument log book" with "Field Equipment Tracking System (FETS)."	
SESDPROC-111-R2, <i>In Situ Water Quality Monitoring</i> , replaces SESDPROC-111-R1	December 7, 2009
SESDPROC-111-R1, <i>In Situ Water Quality Monitoring</i> , replaces SESDPROC-111-R0	November 1, 2007
SESDPROC-111-R0, In Situ Water Quality Monitoring, Original Issue	April 1, 2007

Effective Date: July 19, 2013

TABLE OF CONTENTS

neral Information	4
Purpose	4
•	
Precautions	
1 Safety	4
· · ·	
3 Calibration	
References	6
thodology	7
General	
Real-time Monitoring	7
Unattended Deployment	
	Purpose Scope/Application Documentation/Verification Precautions 1 Safety 2 Equipment Handling 3 Calibration References thodology General Real-time Monitoring Profiling

Contents

1 General Information

1.1 Purpose

The purpose of this procedure is to document acceptable practices in the use of multiparameter data sondes in the monitoring of in situ water quality parameters and dye tracer.

1.2 Scope/Application

This procedure covers the use of multiparameter data sondes for monitoring of in situ water quality including real-time measurement, profiling, and unattended data logging. In situ water quality parameters may include dissolved oxygen (DO), temperature, pH, conductivity, turbidity and chlorophyll. This procedure also applies to use of data sondes for monitoring dye tracer. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 Precautions

1.4.1 Safety

Equipment must be handled in a safe manner. Safety issues related to calibration or measurement of a specific parameter are addressed in individual parameter procedures. In addition, safety precautions should be followed in the deployment of data sondes. For unattended deployment in wadeable systems, data sondes should only be deployed and retrieved under safe flow/stage conditions. When deploying from a bridge, an amber flashing light should be operated on the roof of the field vehicle. When deploying from a boat, standard boating safety procedures should be followed. The SESD Safety, Health and Environmental Management Program Procedures and Policy Manual, provides more information regarding field safety.

1.4.2 Equipment Handling

To ensure the safe and reliable operation of equipment, the manufacturers' directions for transport, cleaning, decontamination, storage and operation shall be followed. In general, upon return from the field and applicable data downloading, the batteries should be removed from the data sonde and the sonde washed via light brushing in warm, soapy water. Each probe should be cleaned and stored as directed by the manufacturer.

Prior to use, data sondes should be signed out in the Field Equipment Tracking System (FETS) according to SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). When unattended deployment is anticipated, pingers should be attached to the sonde, as feasible, to aid in recovery should the sonde be displaced during deployment.

1.4.3 Calibration

Prior to use, each sonde probe should be calibrated according to the specific parameter measurement procedure. However, because the sonde is a multi-probe unit, additional care must be taken to prevent cross-contamination of calibration standards. Similarly, calibration of multiple sonde units requires crosscontamination prevention procedures. Specifically, following immersion of the sonde probes into each calibration standard, all probes should be thoroughly rinsed in distilled or de-ionized water and the excess water shaken off or blotted dry with a lint-free wipe. Conductivity standards are much more sensitive to cross contamination/dilution than other standards; therefore, prior to immersion in a conductivity standard, all probes should be thoroughly rinsed and completely dried with lint-free wipes or compressed air. The conductivity probe on the sondes provides a linear reading of conductivity across the scale, so it is no longer necessary, as in some older technology meters, to calibrate with a standard close to what one may expect in the field. Therefore, due to the propensity of the standard to be easily diluted, one should use a relatively high concentration standard (typically in the 10,000 umho range) for conductivity calibrations.

Besides being easily diluted, conductivity also affects other parameters (specifically DO), therefore conductivity should always be the first parameter calibrated. The recommended order for calibration of the individual probes on a multiparameter sonde is as follows:

- 1. Conductivity
- 2. pH
- 3. DO
- 4. Turbidity/Chlorophyll/Rhodamine in any order

Rhodamine and Chlorophyll probes are calibrated in a similar fashion to turbidity. Specifically, the zero level is set using DI or distilled water followed by calibration to a known standard (typically 100 ppb for Rhodamine).

1.5 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Field Measurement of Dissolved Oxygen, SESDPROC-106. Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

Effective Date: July 19, 2013

2 Methodology

2.1 General

With multiple probe options and customizable configuration, data sondes are extremely versatile tools for the measurement of in situ water quality. Effective use of multiparameter sondes takes additional planning and procedures beyond those described in the individual operating procedures for each parameter (i.e., DO measurement, pH measurement, etc.).

Data sondes may be operated and/or programmed via the manufacturer's display unit or a laptop computer. In either case, it is recommended that the user take the manufacturer's applicable User Manual in the field should difficulties be encountered. If the display unit does not have a power indicator, the batteries should be checked or the unit charged, as applicable, prior to use. Power to the sonde may be supplied by the display unit or by the internal batteries installed in the sonde (a setting on the display unit menu). If the sonde is being powered by the display unit, it is possible to calibrate and set up the sonde for unattended deployment, when in fact there are no batteries in the sonde (the battery voltage being read is for the display unit and not for the sonde). Therefore, it is very important to insure that there are actually batteries in the sonde. Calibration and setting up for an unattended deployment use very little battery power, therefore, it is recommended that sondes be powered from their own internal batteries and not from the display unit. New alkaline or freshly charged nickel metal hydride (NMiH) batteries should be installed in each sonde prior to each field study. Generally, if the sondes will be deployed on multiple occasions during a field study, new alkaline batteries should be installed when the sonde voltage falls below 11.5 volts at end check. Nickel metal hydride (NMiH) batteries operate at a lower voltage than alkaline (1.2 volts vs. 1.5 volts); therefore, if using rechargeable batteries, they should be recharged or replaced if voltage falls below 10.5 volts.

Specific units require that, for the parameters of interest, the appropriate sensor be enabled via the display or laptop prior to use. The field investigator should follow manufacturer's procedures to ensure all required probes are functioning. If a particular parameter is not needed, the sensor should be turned off, via the menu, in order to conserve battery power. It should be noted that turning the reporting of the parameter off does not turn off the probe, it simply turns off the display of the parameter (the parameter is still being logged). One must go into the "Sensor" menu to actually turn off the sensor.

2.2 Real-time Monitoring

Real-time monitoring entails observing monitoring data via display unit or laptop computer as data is collected by the sonde. This data may be recorded in a field log book or logged to the internal memory of the sonde if so equipped. Logged data should be downloaded to a laptop or desktop computer as soon as possible. It is also recommended

SESD Operating Procedure

Page 7 of 9

SESDPROC-111-R3

In Situ Water Quality Monitoring

In Situ Water Quality Mon(111)_AF.R3

that download files be backed up in a separate location (USB thumb drives work very well for this). In addition, even when logging data at regular intervals, it is recommend for real-time monitoring that data also be recorded in a field log book at some, likely less frequent, interval to ensure that some data is captured should the instrument logger fail.

Real-time monitoring generally involves hand-held deployment or attachment to a stationary object at the monitoring location. Hand-held deployments are useful for short-term monitoring in small, wadeable streams. For longer monitoring periods or to hold the sonde at a specific depth, attachment to a fixed object may be more effective. Fixed objects may include rocks or embedded logs already in place at the site or may include fence posts or rods placed by the field investigator prior to monitoring. Sondes may also be hung at desired depths from a boat on larger water bodies.

2.3 Profiling

Profiling involves real-time monitoring or individual measurements at several depths through a water column. Profiling is especially useful for documenting water column gradients or stratification of in situ parameters or for evaluating complete mix conditions in dye tracer studies. Profiling deployments are generally conducted by hand to provide the movement of the sonde through the water column; however, profiling can also be conducted using mechanical/ electrical wench or reel type devices. In profiling applications, the profiling cable should be labeled in some manner to indicate depth or the sonde calibrated for depth. In general, profiling data is recorded in a field log book along with the location and depth information for each measurement.

In fast moving waters it may be necessary to attach weight to the sonde. Weights should always be attached to the probe guard or sonde body, not the individual probes. If attached to the probe guard, weights should be secured in such a way that the weights and attachments do not interfere with probe operation. In all real-time and profiling applications, especially when the sonde is weighted, it is important to ensure that the profiling cable is securely attached to the baling harness of the sonde to prevent a disconnection of the sonde and potential loss or damage to the sonde.

It is important to note that SESD has two general type of sondes, vented and non-vented. Each type of sonde has its own profiling cable. The difference is how the depth sensor works. Non-vented sondes have a standard pressure or depth sensor that can be zeroed out at the site and will then accurately measure depth, typically to within a half a foot or less. Vented sondes have a small hole in the center of the connector pins where the cable attaches and are typically used to accurately (+/- 0.01 feet) measure changes in water stage level in unattended deployments, but may also be used for profiling applications. In order for a vented sonde to accurately measure depth or stage, the sonde MUST be used with a vented cable which vents to the atmosphere. If a vented sonde is used with a vented cable, just zero the depth at the site and measure depth as with a non-vented sonde If a vented sonde is used with a non-vented cable it will NOT give accurate depth

readings. Also, since vented sondes are typically used for stage measurements, the depth sensor is only rated to a maximum depth of 30 feet, whereas non-vented sondes are typically rated to 200 feet.

2.4 Unattended Deployment

Unattended deployment entails pre-programming and deployment of a sonde at a specific location to log monitoring data in the absence of observation by a field investigator. Unattended deployments are useful for collecting data at regular intervals over extended monitoring periods, frequently up to 3-4 days. However, since no data are recorded by hand during the deployment, it is critical that the sonde be correctly programmed.

Programming of the sonde should follow the manufacturer's procedures for unattended deployment. The sonde may be programmed in the lab prior to a field study or programmed in the field. Programming of the sonde is typically accomplished either by the sonde's display unit or by laptop computer. Programming requires input of a start data/time, deployment duration, data log file name, and monitoring interval. Programming times should always be input in local time for the study area, unless otherwise noted in the field log. The field log book should also include the sonde identifier, the date/time of initial deployment, date/time of retrieval, deployment location, and sonde depth. Similarly, recorded times should be in local time for the study area.

In addition to enabling the required probes as described in Section 2.1, some units further require identification of the parameters to include in the logged data file. The field investigator should follow manufacturer's procedures to ensure all necessary data will be successfully logged.

In Situ Water Quality Monitoring

U.S. Environmental Protection Agency Region 4, Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Field Measurement of Oxidation-Reduction Potential (ORP)

Effective Date: April 26, 2017 Number: SESDPROC-113-R2

Author

Name: Brian Striggow

Title: Environmental Engineer

Signature: \mathcal{H} Date: $\mathcal{H} - 20 - 17$

Approval

Name: John Deatrick

Title: Chief, Field Services Branch

Signature: John Date: 4/24/17

Name: Hunter Johnson

Title: Field Quality Manager, Science and Ecosystem Support Division

Signature: 1/20/17

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-113-R2, Field Measurement of Oxidation-Reduction Potential (ORP), replaces SESDPROC-013-R1	April 26, 2017
General: Corrected any typographical, grammatical, and/or editorial errors.	
Title Page: Changed the EIB Chief from Danny France to the Field Services Branch Chief John Deatrick, and the Field Quality Manager from Bobby Lewis to Hunter Johnson.	
Section 2.2: Figure 6 modified for clarity.	
Section 3.3 : Use of overtopping cell described consistent with current practice.	
SESDPROC-113-R1, Field Measurement of Oxidation-Reduction Potential (ORP), replaces SESDPROC-013-R0	January 29, 2013
SESDPROC-113-R0, Field Measurement of Oxidation-Reduction Potential (ORP), Original Issue	August 7, 2009

TABLE OF CONTENTS

1	Gei	neral Information	4
	1.1	Purpose	4
	1.2	Scope/Application	
	1.3	Documentation/Verification	4
	1.4	References	4
	1.5. <i>1.5. 1</i>	General Considerations I Safety	
	1.5.2	2 Records	6
	1.5.3	3 Shipping	6
2	Bac	kground	7
	2.1	General	7
	2.2	Instrumentation	8
	2.3	Redox Chemistry	4
	2.4	Applications	5
	2.5	Limitations	6
3	Met	hodology1	8
	3.1	Standard Solutions	8
	3.2	Verification and Calibration	9
	3.3	Measurement	20
	3.4	Reporting	21

Effective Date: April 26, 2017

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field Oxidation-Reduction Potential (ORP) measurements in aqueous environmental media, including groundwater, surface water and certain wastewater. The measurement of soil ORP is a non-standard measurement and procedures should be developed on a project-specific basis.

1.2 Scope/Application

This document describes procedures generic to all ORP measurement methods to be used by Science and Ecosystem Support Division (SESD) field personnel when collecting and handling samples in the field. On the occasion SESD personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain an ORP measurement, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the SESD LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Faulkner, S.P., W.H. Patrick, Jr., and R.P. Gambrell. 1989. Field techniques for measuring wetland soil parameters. Soil Sci. Soc. Am. J. 53:883-890.

Megonigal, J.P., W.H. Patrick, Jr., and S.P. Faulkner. 1993. Wetland identification in seasonally flooded forest soils: soil morphology and redox dynamics. Soil Sci. Soc. Am. J. 57:140-149.

D.K. Nordstrom and F.D. Wilde. 2005. National Field Manual, Chapter A6, Section 6.5: Reduction Oxidation Potential (Electrode Method). USGS.

Pankow, J.E. 1991. Aquatic chemistry concepts. Lewis Publishers, Inc. Cheleas, Michigan. USA.

Pruitt, B.A. 2001. Hydrologic and soil conditions across hydrogeomorphic settings. Dissertation. The University of Georgia, Athens, GA. USA.

Page 4 of 22

SESD Operating Procedure

SESDPROC-113-R2

Field Measurement of ORP

Field Measurement of ORP(113)_AF.R2

Soil Survey Staff. 1998. Keys to soil taxonomy, 8th Edition. United States Department of Agriculture, Natural Resources Conservation Service, Washington, DC. USA.

Standard Methods. 1992. Standard Methods for the Examination of Water and Wastewater, 18th Edition. Prepared and published jointly by: American Public Health Association, American Water Works Association, Water Environment Federation. American Public Health Association, Washington, DC. USA.

Stumm, W. and J.J. Morgan. 1981. Aquatic chemistry: an introduction emphasizing chemical equilibra in natural waters, 2nd Ed. John Wiley & Sons, New York. USA.

USEPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division, Athens, GA.

USEPA. 2007. Safety, Health and Environmental Management Program Procedures and Policy Manual. Science and Ecosystem Support Division, Region 4, Athens, GA.

Wikipedia entry. Reduction Potential. http://en.wikipedia.org/wiki/Reduction_potential. Retrieved April 2, 2009.

1.5 General Considerations

1.5.1 Safety

Proper safety precautions must be observed when verifying or calibrating instruments for measurement of Oxidation-Reduction Potential. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual (most recent version) and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional.

Reagents commonly used in the preparation of ORP calibration standards are toxic and require care when handling. When using this procedure, avoid exposure to these materials through the use of protective clothing, eye wear and gloves. Safety precautions when handling and preparing verification solutions should include gloves and eyewear to prevent dermal and eye contact, and a mask to avoid inhaling dust particles when handling dry materials. Vigorous flushing should be used if the reagents or solutions come in contact with skin or eyes. Following is specific information on commonly used solutions. The application of the solutions is described in detail in Section 3.1, Standard Solutions, of this procedure.

• Quinhydrone (CAS# 106-34-3) is a skin and respiratory irritant and is poisonous if ingested. Safety precautions when handling quinhydrone should include gloves to prevent dermal contact and a mask to avoid inhaling dust particles when mixing dry

Effective Date: April 26, 2017

- material to prepare calibration standards. Vigorous flushing should be used if concentrated material comes in contact with skin or eyes.
- Zobell's solution is also an irritant and toxic if ingested. The same handling precautions apply when mixing and using Zobell's solution as when using quinhydrone. Zobell's reacts with acid to form harmful byproducts, including hydrocyanide gas.
- Light's solution contains ferro- and ferric-cyanide compounds in sulfuric acid. The components are toxic and burns are possible from contact with this solution.
- Potassium iodide solutions have lower toxicity than most calibration solution options. General ingestion, skin contact, and eye contact precautions apply.

Unused quinhydrone, Zobell's, Light's or other calibration reagents and solutions should be returned to SESD for disposal in accordance with the SESD Safety, Health, and Environmental Management Plan (SHEMP).

1.5.2 Records

Documentation of field activities is done in a bound logbook. All records, including a unique, traceable identifier for the instrument, should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010, most recent version) and the SESD Operating Procedure for Equipment Inventory and Management, (SESDPROC-108, most recent version).

All field ORP measurements pertinent to the sampling event should be recorded in the field logbook for the event as outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010, most recent version), or managed electronically with appropriate backups as described in SESD Operating Procedure for Control of Records (SESDPROC-002, most recent version).

1.5.3 Shipping

Shipped material shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

All shipping documents, such as bills of lading, will be retained by the project leader and stored in a secure place.

2 Background

2.1 General

Oxidation is the process of liberating electrons or gaining oxygen. Examples of oxidation include conversion of elemental iron to rust, elemental sulfur to sulfate, and elemental hydrogen to water (Pankow 1991). Reduction is the process of gaining electrons resulting in the charge on some atomic unit in the species to be reduced. Oxidation-reduction potential (ORP) or redox potential (hereafter, referred to as redox) is a measure of the intensity or activity of an aqueous environment or soil to mediate reactions of important elements in biological systems (e.g., O, N, Mn, Fe, S, and C) and other metallic elements.

Considerable confusion arises on the use of the terms oxidation and reduction as they apply to the media under study. The following introduction reproduced from an online 'Wikipedia' article on the topic lucidly explains their relationship in ORP measurement:

Reduction potential (also known as **redox potential**, **oxidation / reduction potential** or **ORP**) is the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species' affinity for electrons and tendency to be reduced.

In aqueous solutions, the reduction potential is the tendency of the solution to either gain or lose electrons when it is subject to change by introduction of a new species. A solution with a higher (more positive) reduction potential than the new species will have a tendency to gain electrons from the new species (i.e. to be reduced by oxidizing the new species) and a solution with a lower (more negative) reduction potential will have a tendency to lose electrons to the new species (i.e. to be oxidized by reducing the new species). Just as the transfer of hydrogen ions between chemical species determines the pH of an aqueous solution, the transfer of electrons between chemical species determines the reduction potential of an aqueous solution. Like pH, the reduction potential represents an intensity factor. It does not characterize the capacity of the system for oxidation or reduction, in much the same way that pH does not characterize the buffering capacity.

In short, a numerically positive redox potential or ORP represents an environment conducive to the oxidation of an introduced substance by reduction of the original media.

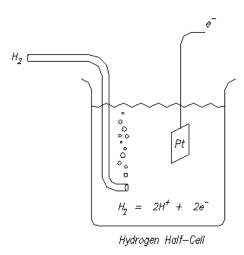
2.2 Instrumentation

ORP measurement systems are a practical implementation of electrochemical cells, which use metal electrodes in a solution to generate an electric current or voltage. If a platinum electrode is immersed in water with hydrogen bubbled into the solution, the H² is oxidized as follows:

$$H^2 = 2H^+ + 2e^-$$

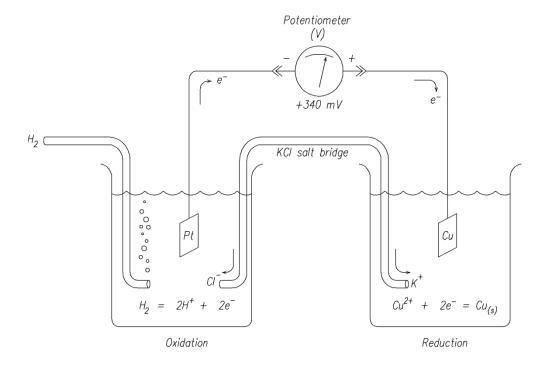
In the electrochemical half-cell illustrated below in Fig.1, hydrogen gas oxidizes to hydrogen ions and free electrons, comprising an oxidation-reduction couple. This couple reaches an equilibrium state that maintains the reference potential of the electrode. The electric potential develops on the wire connected to the platinum electrode, but is difficult to measure in practice in the isolated half-cell. However, when used in a complete electrochemical cell, the cell illustrated is used as a reference to measure other half-cells against, and is called a Standard Hydrogen Electrode (SHE).

Figure 1



If, as shown in Figure 2, a SHE is connected with a salt bridge to a second half-cell in which a reduction reaction is taking place, the electric potential between the two cells can be measured. In the case shown, the potential of the right cell will be +0.34 Volts in reference to the standard hydrogen electrode on the left. This would be represented as an Oxidation Reduction Potential (ORP) of +340mV on the hydrogen scale, or simply as Eh = +340mV.

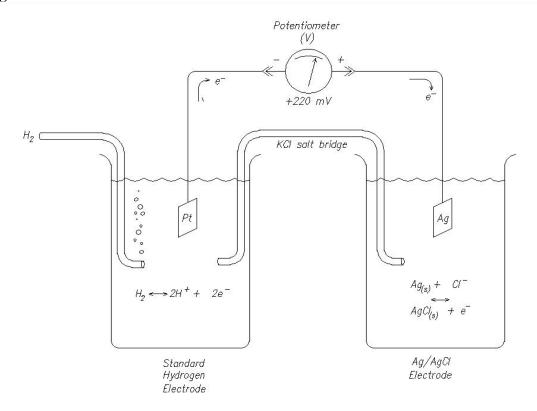
Figure 2



In field practice, the hydrogen electrode is difficult to reproduce. To conduct field measurements, a reference electrode is needed that is simple to maintain and will generate a potential that can be referenced to the standard hydrogen electrode. These requirements are met by the Saturated Calomel Electrode (SCE) and the Silver/Silver Chloride Electrode (SSCE - the SSCE is also commonly identified as an Ag/AgCl electrode). The SCE contains a small amount of elemental mercury, and while useful for certain applications, would rarely be used at SESD. The SSCE or Ag/AgCl electrode is generally used as the reference cell in SESD instrumentation.

In Figure 3 below, a SHE is connected to an Ag/AgCl electrode. In this example of an electrochemical cell, both cells reach an equilibrium potential. At that equilibrium state, the potential of the Ag/AgCl cell is 220mV more positive than the standard hydrogen electrode.

Figure 3



This half-cell potential of the Ag/AgCl electrode in reference to the SHE is used to convert measurements taken with an Ag/AgCl reference back to the hydrogen scale. While the laboratory Ag/AgCl half-cell shown has a potential of +220mV, practical reference cells have varying potentials based on temperature and filling solutions as shown in Table 1 below.

Table 1

Half-cell Potential of Ag/AgCl reference electrode

derived from USGS NFM, Table 6.5.2 (9/2005)

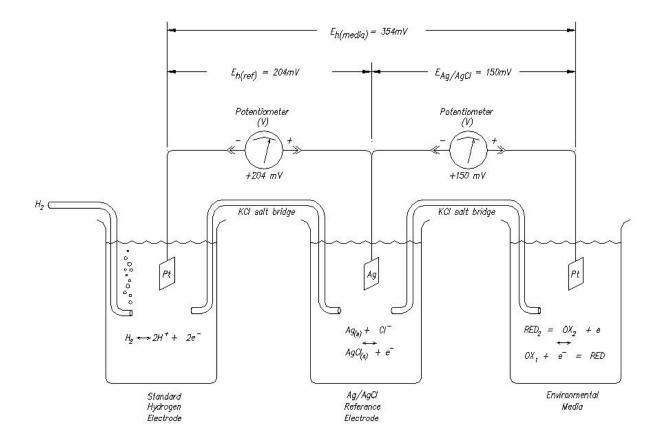
	Molarity of KCI filling solution			
T(°C)	3M	3.3M*	3.5M	Sat/4M
10	220	217	215	214
15	216	214	212	209
20	213	210	208	204
25	209	207	205	199
30	205	203	201	194
35	202	199	197	189
40	198	195	193	184

^{*}interpolated value

Note: YSI sondes and Thermo electrodes typically use 4M KCl filling solutions. Eureka sondes typically use 3.3M KCl filling solutions.

In Figure 4, below, the relationship between a hydrogen electrode, a reference electrode, and a platinum sensing electrode in an arbitrary media is shown. In this case, the ORP of the media in reference to the silver/silver chloride electrode is 150mV. To obtain Eh, the potential of the reference electrode in relation to a hydrogen electrode is added to the potential of the sensing electrode in relation to the reference electrode. In practice, the potential of the reference electrode in relation to a hydrogen electrode is not measured, but obtained from Table 1 above.

Figure 4



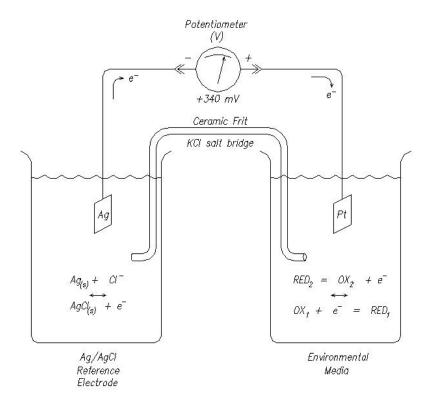
In Figure 5 below, a field instrument is represented as separate electrochemical cells.

The

Effective Date: April 26, 2017

Ag/AgCl reference electrode uses a ceramic frit or other means to provide the essential salt bridge to the environmental media. The platinum sensing electrode is immersed in the environmental media and connected internally in the instrument to measure the potential (voltage) between the two electrodes.

Figure 5



In this illustration, the ORP is measured as 340 mV. This measurement is made in reference to the Ag/AgCl reference electrode and would be reported as such, or as $E_{Ag/AgCl} = 340 \text{mV}$.

In some cases it will be desirable to report the reading on the hydrogen scale, or Eh. To do so, the potential of the reference electrode against the SHE, obtained from Table 1, is added to $E_{Ag/AgCl}$. For our example:

340 mv Measured ORP (E_{Ag/AgCl}) of sample

+ <u>204 mV</u> Eh of Ag/AgCl electrode (ORP of Ag/AgCl electrode referenced to SHE)

544 mV Eh of sample

Both the +340 mV field reading and the adjusted +544 mV Eh can properly be referred to as ORP results. It is only through specifying the reference scale that the ambiguity can be eliminated.

SESD Operating Procedure

Page 12 of 22

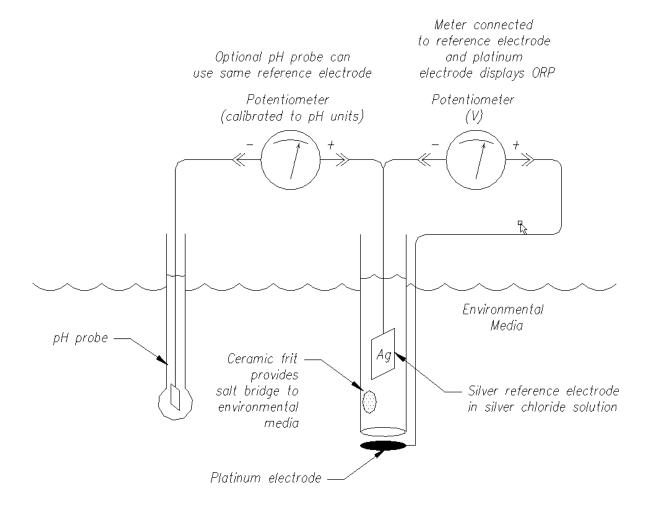
SESDPROC-113-R2

Field Measurement of ORP

Field Measurement of ORP(113)_AF.R2

In Figure 6, below, the theoretical cells shown above have been configured as a practical field instrument. The salt bridge is commonly provided by a ceramic frit connecting the environmental media to the reference electrode. In multi-parameter sondes, the pH probe commonly uses the same reference electrode as the ORP probe.

Figure 6



Redox Chemistry

In acid-base chemistry, the pH of a system is defined as the negative logarithm of the hydrogen ion activity (simplified in practice to the hydrogen ion concentration):

$$pH = -log \{H^+\}$$

Similarly, Pankow (1991) described the negative logarithm of the electron activity (pe) as the master variable for describing the equilibrium position for all redox couples in a given system:

pe /
$$-\log\{e^-\}$$

It can be shown (Pankow) that pe is related to Eh by

Eh = pe*(2.303*R*T)/F

Where:

 $R = gas constant = 8.314 J K^{-1} mol^{-1}$

T = temperature, °K

 $F = Faraday constant = 96.485*10^3 C mol^{-1}$

At 25°C (298°K) this simplifies to

$$E_H = pe * 0.05916$$

And

pe =
$$E_H / 0.05916$$

According to Faulkner et al. (1989) redox is a quantitative measure of electron availability and is indicative of the intensity of oxidation or reduction in both chemical and biological systems. When based on a hydrogen scale, redox (E_H) is derived from the Nernst Equation (Stumm and Morgan 1981):

$$E_{H} = E_{H}^{o} + 2.3 \text{ H (R H T)/nF H log } (9_{i} \{ox\}^{ni}/9_{i} \{red\}^{nj})$$

Where:

 E_{H}^{o} = potential of reference, mV

 $R = gas constant = 81.987 cal deg^{-1} mole^{-1}$

T = temperature, °K

n = number of moles of electrons transferred

F = Faraday constant = 23.061 cal/mole-mv

 $\{ox\}$ and $\{red\}$ = activity of the oxidants and reductants, respectively

SESD Operating Procedure

Page 14 of 22

SESDPROC-113-R2

Field Measurement of ORP

Field Measurement of ORP(113)_AF.R2

2.4 Applications

When interpreted properly, redox combined with other conventional water quality parameters is useful in developing a more complete understanding of water chemistry. Several applications of redox are identified below:

- 1. Redox could be viewed as an extension of the oxygen scale. In this model, the DO probe spans the aerobic scale and the redox probe extends that scale to measure anaerobic conditions. Inferences to geochemistry and chemical speciation can be made from the oxidative state of the system. Application to metal sequestration, metal-iron, -sulfide, methane complexation, and the subsequent bioaccumulation potential is possible.
- 2. Redox can be used to identify anaerobiosis at or near the water column and sediment interface in streams, lakes, and estuaries.
- 3. Redox may be useful in determination of stream jurisdiction and wetland delineation in that it can indicate conditions of soil saturation.
- 4. Based on redox, a pe (or EH) vs. pH stability diagram can be developed to aid in nutrient exchange studies including the timing, release, and partitioning of important water and sediment quality pollutants such as nitrogen and phosphorus species. Most importantly, redox can be used to address error associated with chamber-effect during closed chamber measurements of the water-sediment interface. Redox probes placed inside the contact chamber and inserted approximately ten centimeters into the underlying sediment can be used to monitor changes in sediment redox caused by the chamber, and steps can be taken to reduce chamber-effect.
- 5. Redox may be useful in establishing water and sediment quality standards applicable to wetlands.
- 6. Redox is used to assess the potential of a groundwater system to support various in situ reactions with contaminants, such as reductive dechlorination of chlorinated solvents.
- 7. Redox can provide a useful indicator of conditions that might compromise the performance of Clark-type dissolved oxygen (DO) probes. In general, anaerobic conditions occur at a redox range of +150 mV to +300 mV (pH-dependent and adjusted to hydrogen reference electrode). When redox drops below this level, DO measurements as determined with a Clarke-type probe are highly suspect as the semi-permeable membrane does not discriminate between partial O₂ and sulfides. Consequently, the meter may be reading sulfides.

Effective Date: April 26, 2017

2.5 Limitations

In most environmental media, redox reactions will not reach equilibrium due to low concentrations or multiple redox species. Consequently, redox measurements can generally be considered semi-quantitative in environmental media, unless certain conditions exist.

The USGS in the Interferences and Limitations Section 6.5.3A of their National Field Manual succinctly describe some of the issues encountered in the application of ORP measurements. This section is reproduced here, unedited:

6.5.3.A INTERFERENCES AND LIMITATIONS

Measurements should not be carried out without an awareness of the interferences and limitations inherent in the method.

- Organic matter and sulfide may cause contamination of the electrode surface, salt bridge, or internal electrolyte, which can cause drift or erratic performance when reference electrodes are used (American Public Health Association and others, 2001).
- Hydrogen sulfide can produce a coating on the platinum electrode that interferes with the measurement if the electrode is left in sulfide-rich water for several hours (Whitfield, 1974; Sato, 1960).
- The platinum single and combination redox electrodes may yield unstable readings in solutions containing chromium, uranium, vanadium, or titanium ions and other ions that are stronger reducing agents than hydrogen or platinum (Orion Research Instruction Manual, written commun., 1991).
- Do not insert redox electrodes into iron-rich waters directly after the electrode(s) contact ZoBell's. An insoluble blue precipitate coats the electrode surface because of an immediate reaction between ferro- and ferricyanide ions in ZoBell's with ferrous and ferric ions in the sample water, causing erratic readings.

Many elements with more than one oxidation state do not exhibit reversible behavior at the platinum electrode surface and some systems will give mixed potentials, depending on the presence of several different couples (Barcelona and others, 1989; Bricker, 1982, p. 59–65; Stumm and Morgan, 1981, p. 490–495; Bricker, 1965, p. 65). Methane, bicarbonate, nitrogen gas, sulfate, and dissolved oxygen generally are not in equilibrium with platinum electrodes (Berner, 1981).

TECHNICAL NOTE:

Misconceptions regarding the analogy between Eh (pe) and pH as master variables and limitations on the interpretation of Eh measurements are explained in Hostettler (1984), Lindberg and Runnells (1984), Thorstenson (1984), and Berner (1981). To summarize:

SESD Operating Procedure

Page 16 of 22 SESDPROC-113-R2

Field Measurement of ORP

Field Measurement of ORP(113)_AF.R2

- (1) Hydrated electrons do not exist in meaningful concentrations in most aqueous systems—in contrast, pH represents real activities of hydrated protons. Eh may be expressed as pe (the negative logarithm of the electron activity), but conversion to pe offers no advantage when dealing with measured potentials.
- (2) Do not assume that redox species coexist in equilibrium. Many situations have been documented in which dissolved oxygen coexists with hydrogen sulfide, methane, and ferrous iron.
 - The practicality of Eh measurements is limited to iron in acidic mine waters and sulfide in waters undergoing sulfate reduction.
 - Other redox species are not sufficiently electroactive to establish an equilibrium potential at the surface of the conducting electrode.
- (3) A single redox potential cannot be assigned to a disequilibrium system, nor can it be assigned to a water sample without specifying the particular redox species to which it refers. Different redox elements (iron, manganese, sulfur, selenium, arsenic) tend not to reach overall equilibrium in most natural water systems; therefore, a single Eh measurement generally does not represent the system.

3 Methodology

3.1 Standard Solutions

Care should be taken not to contaminate standards and samples and to verify the expiration date of all standards prior to use. All meters should be verified or calibrated according to the manufacturer's procedures.

Standard solutions for calibration and verification should be selected to meet project requirements. SESD generally maintains a stock of Zobell's solution suitable for most projects. The characteristics and use of the common standard solutions are described below.

- Zobell's solution contains potassium ferri- and ferro- cyanide compounds. The solution is available as prepared solutions or premeasured reagents for mixing by the user. Zobell's has moderate toxicity but will react with acid to form harmful byproducts, including hydrocyanide gas. It has a shelf life ranging from several days to several months depending on the manufacturer. Stock and working solutions of Zobell's should be stored in dark bottles due to its light sensitivity.
- Quinhydrone solutions are mixed at the time of use by adding quinhydrone to pH 4 or pH 7 buffers. At 25°C, the E_h of quinhydrone pH 4 and pH 7 verification solutions are 462mV and 285mV respectively. An advantage of quinhydrone solutions is that they offer a span of calibration points that may be appropriate for particular applications. Quinhydrone is a lightly 'poised' solution in that it offers less driving force towards the calibration point: a compromised instrument is more likely to be revealed in a quinhydrone calibration. A quinhydrone calibration/verification solution is created by adding 10g of quinhydrone to 1L of pH 4 or pH 7 buffer solution (ASTM D1498). The solutions are mixed on a magnetic mixing plate for a minimum of 15 minutes to create a saturated solution with undissolved crystals remaining. Quinhydrone solutions are usable for 8 hrs from the time of mixing.
- Light's solution consists of ferrous and ferric ammonium sulphate in sulphuric acid. The solution would rarely be used at SESD due to its high acidity and associated handling difficulty. Spent solutions with a pH<2 would be regulated as a hazardous waste. Light's is a highly poised solution that may allow a marginally functioning electrode to pass calibration.
- A prepared potassium iodide solution is available which has low toxicity and a long shelf life. The solution may stain clothing or surfaces if spilled.

3.2 Verification and Calibration

ORP instruments may be **verified** or **calibrated**, depending on the application. The approach chosen should be selected based on project needs and information presented in Section 2.4., Limitations. Standard laboratory practice in making ORP measurements is to **verify** the accuracy of the instrument prior to use, and this practice should be followed when true quantitative results are required. In a **verification**, the instrument in its direct-reading mode is checked against a standard solution in a pass/no-pass test, and no corrections are applied to subsequent measurements. In most applications, the ORP information is used semi-quantitatively and for these applications, the instruments may be **calibrated** to the standard solutions. In an instrument **calibration**, the instrument probe is placed in the standard solution and the difference between the standard measurement and the known ORP value of the standard is used by the instrument to make adjustments to the subsequent measurements.

In **verification** of an ORP instrument, the instrument is set to absolute mV reading mode or the internal calibration offset is zeroed out. The instrument probe should then be placed in the standard solution and the reading verified to fall within +/-10mV of the predicted reading for the standard. Instruments with single-purpose electrodes are most suitable for this approach. If the instrument fails the verification, standard solution quality should be considered and instrument maintenance performed per the manufacturer's procedures.

In most SESD field practice, the end data use is semi-quantitative. In this case, the instruments can be **calibrated** to standard solutions appropriate for the project using the manufacturer's recommended procedure. One minute after the calibration, the instrument should display a stable reading within +/-10mV of the predicted reading. An instrument failing this test should be recalibrated to determine if the problem is inadequate equilibration time. In the event of continued instrument failure, aging or contamination of the standard solution should be considered. Subsequently the electrode should be serviced according to the manufacturer's procedures. Common service procedures include cleaning the platinum electrode with mild abrasives or acids and refilling or replacing the reference electrode.

Prior to a mobilization, all ORP instruments will be checked for proper operation and verified or calibrated against standard solutions. During the field mobilization, each instrument will be calibrated or verified prior to, and verified after, each day's use or deployment.

Even though it is not necessary to re-calibrate ORP instrument at regular intervals during the day, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an extreme temperature change or submersion of a filling solution port have impacted the instrument's performance. If an operational check is warranted, the field operator should follow the appropriate verification/calibration steps as described above.

The predicted ORP values of standard solutions will be obtained from the manufacturer of prepared solutions, literature, or appropriate values listed in this procedure. Care is in order, as the predicted ORP value is specific for the type of reference electrode used by the probe (either Ag/AgCl or calomel) and the molarity of the filling solution in the reference electrode. To use the

solution with another electrode or filling solution, the expected ORP readings for the solution should be converted to Eh for the probes intended for the solution as per the Reporting section of this procedure. Then a table can be compiled for the electrode in use by subtracting the $E_{h,ref}$ for the electrode and filling solution in use. This will be done at the Field Equipment Center (FEC) for the solutions stocked.

Verification solutions should be managed per the manufacturer's directions regarding storage and handling. After instrument verification or calibration, the solution cannot be returned to the stock solution container, although a separate container of working solution can be maintained.

Spent solutions and working solutions should be returned from the field to the SESD laboratory for proper disposal by the SHEMP, or handled as directed by the SHEMP. Properly handled stock solutions may be returned to the FEC for use at that facility.

3.3 Measurement

ORP measurements should be conducted in a fashion that prevents the addition or loss of any potential oxidants or reductants. Results could be compromised by exposing the sample to air or allowing H₂S to off-gas from anoxic samples. Like dissolved oxygen measurements, ORP measurements should be conducted in situ or by using a flow-through cell evacuated of air (see the SESD Operating Procedure for Field Measurement of Dissolved Oxygen (SESDPROC-106, most recent version). Good results are commonly obtained with the use of an overtopping cell where the environmental media is pumped into the bottom of a narrow cup (generally field fabricated from a sample container) containing the instrument sensors. The sensors are continually flushed with fresh media as the cup is allowed to overflow. Caution should be exercised at very low flow rates where the media in the cup could potentially re-oxygenate.

When using multi-parameter probes for ORP measurements, the general guidelines for probe deployment described in the SESD Operating Procedure for Field Measurement of Dissolved Oxygen (SESDPROC-106, most recent version) and the SESD Operating Procedure for In situ Water Quality Monitoring (SESDPROC-111, most recent version) apply.

ORP probes must be operated and maintained in accordance with the manufacturer's instructions. Reference electrodes in multi-parameter probes may require regular filling or replacement. Single parameter ORP electrodes may require regular filling and operation in an upright position to assure that proper salt bridge flow is maintained. Platinum electrode surfaces are easily contaminated and polishing or cleaning of the electrodes should be performed as recommended by the manufacturer.

Measurements in field logbooks should be recorded to the nearest mV. The type of reference electrode in use and its filling solution should be recorded in at least one logbook as part of the field project records.

ORP is a temperature sensitive measurement, but ORP instruments are not temperature compensated. Consequently, the media temperature should always be recorded at the same time

SESD Operating Procedure Field Measurement of ORP Page 20 of 22

SESDPROC-113-R2

Field Measurement of ORP(113)_AF.R2

as the ORP is recorded. Likewise, as ORP is often pH dependent, pH should also be recorded at the time of ORP measurement.

3.4 Reporting

In the absence of a specified reference scale, ORP data has no meaning. Therefore, the reference scale used should always be specified in reporting or discussing the ORP data. ORP measurements converted to a hydrogen scale can be reported as " E_h ". Data reported as the direct field measurement without correction might be described as "ORP referenced to Ag/AgCl electrode" or " $E_{Ag/AgCl}$ ". The expectations of the data user should be ascertained or the measurements should be reported in both systems.

To apply corrections to obtain E_h from the direct field measurement, the known half-cell potential of the reference electrode is added to the recorded field ORP value:

$$E_{h,sample} = ORP_{sample} + half-cell potential of reference electrode$$

The following table, reproduced from Section 2.2, presents the half-cell potential of a silver/silver chloride reference electrode at various temperatures and with various molarities of KCl filling solutions.

Table 1

Half-cell Potential of Ag/AgCl reference electrode

derived from USGS NFM, Table 6.5.2 (9/2005)

	Molarity of KCI filling solution			
T(°C)	3M	3.3M*	3.5M	Sat/4M
10	220	217	215	214
15	216	214	212	209
20	213	210	208	204
25	209	207	205	199
30	205	203	201	194
35	202	199	197	189
40	198	195	193	184

^{*}interpolated value

Note: YSI sondes and Thermo electrodes typically use 4M KCl filling solutions. Eureka sondes typically use 3.3M KCl filling solutions

Example:

A multi-parameter probe with a silver/silver chloride reference electrode and 4M KCl filling solution is used to record a stream ORP measurement of 146mV. The stream temperature is recorded as 15°C.

From the above table, the half-cell potential of an Ag/AgCl reference electrode filled with 4M KCl is 209mV at 15°C. Then:

$$E_{h,sample} = ORP_{Ag/AgCl,sample} + half-cell potential of Ag/AgCl reference electrode$$

$$E_{h,sample} = 146 mV + 209 mV \\$$

$$E_{h,sample} = 355 \text{mV}$$

As noted in Section 3.3, Measurement, ORP measurements are sensitive to temperature, and may be sensitive to pH. As the instruments do not compensate for these parameters, ORP data should always be reported with the temperature and pH of the media at the time of measurement.

Final reporting values of Eh or ORP should be rounded to the nearest 10mV. The following spreadsheet formula can perform the rounding of an interim result located in spreadsheet cell 'A1': =INT(A1/10+0.5)*10

Effective Date: April 26, 2017

Region 4

U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Management of Investigation Derived Waste
8
Effective Date: July 3, 2014 Number: SESDPROC-202-R3
Authors
Name: Art Masters
Title: Environmental Scientist, Regional Expert
Signature: Date: 7/2/14
Annuovala
Approvals
Name: John Deatrick
Title: Acting Chief, Enforcement and Investigations Branch
Signature: The Death in Date: 7/2/14
Name: Mike Bowden
Title: Acting Chief, Ecological Assessment Branch
Title: Acting Chief, Ecological Assessment Branch Signature: Date: 7/4/14
Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 7/2/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-202-R3, Management of Investigation Derived Waste, replaces SESDPROC-202-R2.	July 3, 2014
General: Corrected typographical, grammatical and/or editorial errors.	
Cover Page: The Enforcement and Investigations Branch Chief was changed from Archie Lee to Acting Chief John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Mike Bowden. The FQM was changed from Liza Montalvo to Bobby Lewis. Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
SESDPROC-202-R2, Management of Investigation Derived Waste, replaces SESDPROC-202-R1.	October 15, 2010
SESDPROC-202-R1, Management of Investigation Derived Waste, replaces SESDPROC-202-R0.	November 1, 2007
SESDPROC-202-R0, Management of Investigation Derived Waste, Original Issue	February 05, 2007

Effective Date: July 3, 2014

TABLE OF CONTENTS

1	General Information	4
	1.1 Purpose	4
	1.2 Scope/Application	4
	1.3 Documentation/Verification	
	1.4 References	4
	1.5 General Precautions	5
	1.5.1 Safety	5
	1.5.2 Procedural Precautions	
2	Types of Investigation Derived Waste	6
3		
4		
	TABLES	
Т	Fable 1: Disposal of IDW	9

Contents

1 General Information

1.1 Purpose

This document describes general and specific procedures and considerations to be used and observed when managing investigation derived waste (IDW) generated during the course of hazardous waste site investigations.

1.2 Scope/Application

The procedures and management options for the different categories of IDW described in this document are to be used by SESD field personnel to manage IDW generated during site investigations. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW generated at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

SESD Operating Procedure

Page 4 of 9

SESDPROC-202-R3

Management of Investigation Derived Waste

Management of IDW(202)_AF.R3

1.5 **General Precautions**

1.5.1 Safety

Proper safety precautions must be observed when managing IDW. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when managing IDW:

- Due to time limitations and restrictions posed by RCRA regulations on storage of hazardous waste, accumulation start dates should be identified on all drums, buckets or other containers used to hold IDW so that it can be managed in a timely manner.
- During generation of both non-hazardous and hazardous IDW, keep hazardous IDW segregated from non-hazardous IDW to minimize the volume of hazardous IDW that must be properly managed.

Effective Date: July 3, 2014

Management of Investigation Derived Waste

Types of Investigation Derived Waste 2

Materials which may become IDW include, but are not limited to:

- Personal protective equipment (PPE) This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment and items This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand augering.
- Drilling mud or water used for mud or water rotary drilling.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as spent solvents and wash water.
- Packing and shipping materials.

Table 1, found at the end of this procedure, lists the types of IDW commonly generated during field investigations and the current disposal practices for these materials.

For the purpose of determining the ultimate disposition of IDW, it is typically distinguished as being either hazardous or non-hazardous. This determination is based on either clear regulatory guidance or by subsequent analysis. This determination and subsequent management is the responsibility of the program site manager.

3 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW should be addressed in the study plan or QAPP for the investigation. To reduce the volume of any IDW transported back to the Field Equipment Center (FEC), it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum.

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard into the facility's dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site.

Disposal of non-hazardous IDW such as drill cuttings, drilling mud, purge or development water, decontamination wash water, etc., should be specified in the approved study plan or QAPP. It is recommended that these materials be placed into a unit with an environmental permit, such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facility's treatment system. It may be feasible to spread drill cuttings around the borehole, or, if the well is temporary, to place the cuttings back into the borehole. Non-hazardous monitoring well purge or development water may also be poured onto the ground down gradient of the monitoring well when site conditions permit. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements for this subsection are:

- Non-hazardous liquid and soil/sediment IDW may be placed on the ground or returned to the source if doing so does not endanger human health or the environment or violate federal or state regulations. Under no circumstances, however, should monitoring well purge water be placed back into the well from which it came.
- Soap and water decontamination fluids and rinsates of such cannot be placed in any water bodies and must be collected and returned to the FEC for disposition.
- The collection, handling and proposed disposal method must be specified in the approved study plan or QAPP.

Page 7 of 9

4 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan or QAPP for the study or investigation. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed in the source area from which they originated if doing so does not endanger human health or the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to allow arrangements for proper containerization, labeling, transportation and disposal/treatment in accordance with USEPA regulations.

The generation of hazardous IDW should be minimized to conserve Division resources. Most routine studies should not produce any hazardous IDW, with the possible exception of spent solvents and, possibly, purged groundwater. The use of solvents during field cleaning of equipment should be minimized by using solvent-free cleaning procedures for routine cleaning and decontamination (see SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205). If solvents are needed, the volume should be minimized by using only the amount necessary and by capturing the residual solvent separately from the aqueous decontamination fluids (detergent/wash water mixes and water rinses).

At a minimum, the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be left on-site with the permission of site operator and proper disposal arranged.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

Page 8 of 9

Effective Date: July 3, 2014

Table 1: Disposal of IDW

ТҮРЕ	HAZARDOUS	NON - HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per SESDPROC-205, and return to FEC.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator and arrange for proper disposal.	N/A
Soil Cuttings	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in a 55-gallon steel drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Groundwater	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Decontamination Water	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. Decontamination water may also be disposed in a sanitary sewer system, with permission from the wastewater treatment plant representative, and if doing so does not endanger human health or the environment, or violate federal or state regulations.
Disposable Equipment	Containerize in DOT-approved container or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. If unfeasible, return to FEC for disposal in dumpster.
Trash	N/A	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

^{**} These materials may be placed on the ground if doing so does not endanger human health or the environment or violate federal or state regulations.

SESD Operating Procedure Page 9 of 9 SESDPROC-202-R3

Management of Investigation Derived Waste Management of IDW(202)_AF.R3

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

mid P O A'
Title: Pump Operation
Effective Date: September 12, 2013 Number: SESDPROC-203-R3
Authors
Name: Tim Simpson
Title: Environmental Scientist, Regional Expert
11
Signature: In Date: 09/12/2013
Approvals
Approvais
Name: Danpy France
Title: Chief, Enforcement and Investigations Branch
Signature: Date: 9/2/13
Name: John Deatrick
Title: Chief, Ecological Assessment Branch
Signature: Oh Deatril Date: 9/12/12
Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: 1/12/13

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-203-R3, <i>Pump Operation</i> , replaces SESDPROC-203-R2.	September 12, 2013
General: Corrected any typographical, grammatical, and/or editorial errors.	
Cover Page: Changed the Enforcement and Investigations Branch Chief from Archie Lee to Danny France. Changed the Ecological Assessment Branch Chief from Bill Cosgrove to John Deatrick. Changed the FQM from Laura Ackerman to Bobby Lewis.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
Section 1.2: Added the following statement - Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.	
Section 2.1: Rewrote entire section.	
Section 2.2 : Rewrote entire section. Replaced eight step procedure describing peristaltic pump purging with five step procedure.	
Section 2.3 : Rewrote first paragraph. Removed six step procedure regarding sampling with a peristaltic pump.	
Section 3.1: Edited the note in the first paragraph regarding pump overheating.	
Section 3.2 : Removed language in bullet one regarding grounding the pump, modified bullet 3 to add checking well with PID/FI, Added bullet stating not to touch steel well casings or other metal objects when pump is energized.	
Section 3.3 : Removed sentence to test generator, Removed section stating to open the pump water reservoir.	
Section 3.4: Minor edits to last two sentences of bullet four.	
Section 3.5 : Added two sentences to the end of bullet 5 regarding pump airlock.	

Section 3.6 : Minor edits of trouble shooting points 1 and 3. Added second sentence to problem 6. Rewrote solution for problem 6 to state using a cooling shroud.	
Section 4.1: Rewrote entire section.	
Section 4.2: Rewrote entire section.	
Section 4.3: Rewrote entire trouble shooting section.	
Section 5.1: Added "installed by direct push technology (DPT)" to the first sentence.	
Section 5.2 : Added sentence two and three regarding the bladder pump. Edited bullet one to state "assemble the bladder pump with a new bladder". Rewrote bullets 2-10.	
Section 5.3: Removed Section 5.3 (Trouble Shooting).	
Section 6.1: Rewrote the first paragraph.	
Section 6.2 : Rewrote bullets 1, 2 and 5. Added bullet 2. Edited last sentence of bullet 4.	
SESDPROC-203-R2, <i>Pump Operation</i> , replaces SESDPROC-203-R1.	November 6, 2009
SESDPROC-203-R1, Pump Operation, replaces SESDPROC-203-R0.	November 1, 2007
SESDPROC-203-R0, Pump Operation, Original Issue	February 05, 2007

Effective Date: September 12, 2013

TABLE OF CONTENTS

1	Gen	eral Information	. 5
	1.1	Purpose	. 5
	1.2	Scope/Application	. 5
	1.3	Documentation/Verification	. 5
	1.4	References	. 5
	1.5	General Precautions	
		Safety	
_		Procedural Precautions	
2	Geo	-tech Geopump TM Peristaltic Pump	. 7
	2.1	General	. 7
	2.2	Operation	. 7
	2.3	Sampling with a Peristaltic Pump	. 7
3	Sma	all Diameter Electric Submersible Pumps	
	3.1	General	. 9
	3.2	Safety	. 9
	3.3	Pre-Loadout Checkout Procedures	10
	3.4	Operation	10
	3.5	Maintenance and Precautions	10
	3.6	Trouble Shooting	11
4	Geo	tech Portable Bladder Pump	12
	4.1	General	12
	4.2	Operation	12
	4.3	Trouble Shooting	14
5	Geo	probe® Model MBP 470 Mechanical Bladder Pump 1	15
	5.1	General	15
	5.2	Operations	15
6		tial Pump (Geoprobe® or Waterra®)	
	6.1	General	17
	6.2	Operation	17

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when operating a variety of pumps that may be used for purging monitoring wells and for collecting samples of aqueous phase environmental media, including groundwater, surface water and certain wastewaters, for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when using pumps during the process of collecting samples of aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain samples of the particular media of interest, and that another method or pump must be used to obtain said sample, use of the variant pump and/or procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Groundwater Sampling, SESDPROC-301, Most Recent Version

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when operating the pumps described in this section. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when operating pumps used for collecting samples of aqueous environmental media:

- When using pumps for collection of environmental samples, always work from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for crosscontamination to occur during sampling.
- Observe limitations of certain pumps for collection of certain analyte groups (SESD Operating Procedure for Groundwater Sampling (SESDPROC-301), Section 2, Special Sample Considerations).
- Documentation of field sampling is done in a bound logbook.
- Observe appropriate safety and cross-contamination precautions when operating pumps powered by gasoline-powered generators.

2 Geo-tech GeopumpTM Peristaltic Pump

2.1 General

These pumps are generally small, light-weight, portable and are powered by 12-volt batteries. The limit of suction is approximately 25 - 27 feet of vertical separation between the pump and water surface. They are appropriate for surface water sampling and for groundwater sampling where relatively small volumes of water are required for purging and sampling, and the water level is within the limit of suction.

2.2 Operation

- 1. The Geopump has two drive locations that the roller pump head can be fastened depending on anticipated use. In most cases the pump head should be attached in the 0-600RPM drive location. Where very low flow rates and fine control is required, the pump head can be attached to the 0-300 RPM drive location.
- 2. Connect the pump power cable to a 12 volt power source. Briefly turn the pump on to test.
- 3. Open the pump head with the lever and place a clean 9"-12" length of Silastic® flexible tubing in the head v-slots and reclose the head. New Silastic® tubing should be used for each sample. When the pump is run for extensive periods, it may be necessary to replace the Silastic® tubing or reposition it on the rollers.
- 4 Attach sample tubing to one end of the Silastic® tubing by inserting it approximately 1" into the sample tubing. Attach a discharge tubing similarly to the other end of the flexible tubing and position the discharge appropriately, The tubing should fit snugly.
- 5. Set the direction switch on the pump face in the direction of desired pump flow. Turn on the pump and set the rheostat to the desired pump speed.

2.3 Sampling with a Peristaltic Pump

It is not acceptable to collect samples for organic compounds analyses through the flexible tubing used in the pump head due to possible sorbtion of contaminants and contribution of stray organic compounds to the sample. When collecting samples for non-volatile organic compound analyses it is necessary to use a vacuum container placed

in the sample line. Volatile organic compounds must be sampled using the 'soda-straw' method. The use of the vacuum container and the 'soda-straw' method is explained in Groundwater Sampling Procedure SESDPROC-301. Samples of some inorganic constituents (i.e., metals and cyanide) may be collected directly through the tubing if a rinse blank of the tubing is collected.

3 Small Diameter Electric Submersible Pumps

3.1 General

Included within this category is the Grundfos® Redi-Flo2 small diameter electric submersible pump. With a diameter of approximately 1.75 inches, it is designed to be used in 2-inch diameter and larger wells. (Note: If used in any well larger than 4-inch diameter, this pump must be equipped with a cooling shroud to prevent the pump from overheating. If the pump overheats, internal sensors shut-off the pump it will not be operable until it cools to a temperature within the operating range). The Redi-Flo2® is a variable speed pump capable of providing pump rates from less than 100 ml/minute to in excess of 8 gallons per minute.

The Redi-Flo2 pump, depending on the controller being used, operates with either 115v or 220v power. The pump rate is controlled by adjusting the frequency of the current going to the pump motor. It is a light-weight pump and can be easily handled by one person when lowering, but two people are generally needed when removing the pump, one to pull and another to reel in the hose and power lead.

3.2 Safety

- 1. Place the generator on dry ground or plastic sheeting as far as practical from the well, in the down-wind direction.
- 2. Inspect the electrical extension cord, as well as the lead to the pump, for frays, breaks, exposed wiring, etc.
- 3. Where appropriate, check the head space of the well for the presence of an explosive atmosphere with a combustible gas meter, or for vapors with a PID/FID instrument.
- 4. Wear rubber boots in wet areas to insulate against shock hazards.
- 5. Take care not to touch steel well casings, the controller housing, cabling, or other metal objects while the pump is energized.
- 6 If purge water is not collected, direct the discharge away from the well and generator, preferably down gradient of the area.
- 7 Make sure that the generator is set to the proper voltage.
- 8. Do not add gasoline or oil to the generator while it is running.

9Store the generator, gasoline, and oil in a trailer dedicated to this type of equipment. Do not haul this equipment in the back of any passenger vehicle or with any sampling equipment or containers.

3.3 Pre-Loadout Checkout Procedures

- 1. Check the oil and gasoline in the generator. Take the generator outside and start. Place a load on the generator, if possible.
- 2. Inspect the pump and all hoses, rope, and electrical cord and connections.

3.4 Operation

- 1. Place the pump, the controller, and enough hose for the measured well depth on plastic sheeting next to the well. Set the generator in a dry, safe location downwind of the well, but do not plug the cord from the controller into the generator.
- 2. Lower the pump, power lead, and hose into the well, placing the pump approximately five feet into the water column.
- 3. Start the generator, <u>then</u> connect the power cord from the pump controller. Make sure the proper voltage has been selected.
- 4. After starting the pump, closely observe operation to determine if drawdown is occurring in the well. If the water level is not pulled down, raise the pump in the water column one to two feet from the top of the water column and continue to purge. If the water level drops, however, lower the pump to keep up with the drawdown. Do not allow the pump to run dry. This condition can create a thermal overload and shut the pump down. Repeated thermal overloads may damage the pump and will create delays in sampling.

3.5 Maintenance and Precautions

- 1. Empty the hose of contaminated water before leaving the sampling location. Do not bring the hose back to the FEC if it contains purge water from a site.
- 2. Field clean the pump prior to using at the next sampling location in accordance with the SESD Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).
- 3. Do not run the generator without first checking the oil.
- 4. Do not put the pump in the trailer with the generator.

Effective Date: September 12, 2013

5. If the pump is equipped with a check valve or back flow preventer, periodically check this device to make sure that it is operating. This is a common place for debris or other material to accumulate and interfere with the proper operation of the device. If the water level in a well pulls down to below the pump inlet when operating with a check valve, the pump can airlock. The airlock can be relieved by surging the pump or pulling the pump from the well and draining the hose or tubing.

3.6 Trouble Shooting

Generator running,	1.	Loose wiring connection .	1.	Check all connections. Repair as needed. (Generator off!!)
no pump output	2.	Cord unplugged at generator.	2.	Plug pump back in.
	3.	Over voltage or Under voltage on controller display.	3.	Adjust generator output/idle speed; allow generator more warm-up time. Use larger or shorter extension cord.
	4.	Pump out of water.	4.	Lower pump into water.
	5.	Hose collapsed or kinked.	5.	Un-kink hose.
	6.	Pump will not run or shuts down with thermal overload signal. Display indicates zero amps.	6.	Use cooling shroud in wells larger than 2".

4 Geotech Portable Bladder Pump

4.1 General

The Geotech Portable Bladder Pumps is primarily suitable for low-flow purging and sampling of wells as small as ¾" casing diameter. As deployed by SESD, the system uses the GeoControl Pro portable compressor/controller to power the downhole bladder and check valve mechanism.

In operation, the pump is connected to drive tubing and sample tubing. On each pump cycle, the drive tube pressurizes a tubular bladder, compressing it inward and forcing well water through an upper check valve and up the discharge sample tubing to the surface. On release of pressure, the bladder relaxes, allowing water to enter the lower check valve from the well. The pumps are available in 1.5", 0.85", and 0.675" diameters. As of this revision, SESD owns a 0.85" pump, but these instructions apply to all pumps in the series.

Bladder pump operation slows with increasing length of the drive tubing. As the volume of this tubing increases with length, the controller requires longer times to pressurize and depressurize the pump on each cycle. In wells with a tall water column, this effect can be minimized by the use of a drop tube. The pump is positioned submerged but near the top of the water column and the drop tube extends to the sampling interval. The drop tube conducts water from the sampling interval to the pump and the controller only has to pressurize enough drive tubing to reach the water surface.

4.2 Operation

- 1. Prepare the pump by connecting sample tubing to the central barb fitting and drive tubing to the outer barb fitting. The sample tubing should be new tubing suitable for the work, generally teflon. The drive tubing can be teflon or poly tubing and may be field cleaned between wells with the pump. If used, fasten a measured drop tube of new sample tubing to the lower barb on the pump and to a pickup screen.
- 2. Lower the pump into the well and locate it at the desired sampling interval.
- 3. Cut the tubing to suitable above-ground working lengths, allowing drive tubing to reach the controller and sample tubing to reach a bucket or flow-through cell. Connect the drive tubing to the controller.
- 4. Turn the controller on. As a starting point, the discharge time should allow the air line to pressurize to about 1 psi for each foot the water level is below

- ground surface. The fill time should initially be set to allow the air pressure to return to zero at the end of each cycle.
- 5. If the pump does not discharge or is still discharging at the end of the pressure cycle, the discharge time can be increased. The fill time can be adjusted for maximum or desired flow.

4.3 Trouble Shooting

Air in Sample Line	1.	Damaged bladder or Orings or bladder shifted	1.	Inspect and replace. Limit air pressure to pump.
	2.	Outgassing of sample.	2.	no action required.
No sample line output	1.	Pump above water	1.	Check and adjust pump level. Reduce output to achieve stable drawdown.
	2.	Kinked drive or sample tubing	2.	Check tubing and remedy.
	3.	Inadequate air pressure.	3.	Increase discharge time
	4.	Silt in check valve.	4.	Surge pump in well or remove from well and clean. Consider further well development with alternate pump.

5 Geoprobe® Model MBP 470 Mechanical Bladder Pump

5.1 General

The Geoprobe® Model MBP 470 Mechanical Bladder Pump can be used for purging small diameter temporary monitoring wells installed by direct push technology (DPT). These pumps represent one of only a few types of pumps that are capable of fitting inside the ID of the probe rod and that are also capable of pumping ground water whose water level is below the limit of suction.

5.2 Operations

The Geoprobe® Model MBP 470 Mechanical Bladder Pump operates by manually or mechanically cycling a corrugated FEP Teflon® bladder contained within a small diameter pump body. The bladder is actuated by movement of a smaller diameter sample tubing within an outer tubing which positions and stabilizes the pump. As this pump is sensitive to silt, it is generally advantageous to develop the well first with an impulse pump before deploying the mechanical bladder pump for purging and sampling. The basic operation is as follows.

- 1. Following manufacturers guidelines, assemble the bladder pump with a new bladder.
- 2. Attach the pump to the larger diameter outer tubing by screwing it onto the tubing. The pump will cut shallow threads into the tubing.
- 3. Lower the pump into the well to the desired sampling interval. Note that it will be very difficult to reposition the pump later, often requiring recutting and redeploying the tubing system.
- 4. While holding the downhole tubing securely, cut off the tubing near the top of the well.
- 5. Using gravity as an aid, thread the sample tubing (generally teflon®) down into the outer tubing until it bottoms out against the pump. Cut off the sample tubing at a convenient length to reach a discharge bucket or flow-through cell. Remove the pump and the tubing assembly from the well.
- 6. Unscrew the pump from the outer tubing. Either push and shake the inner tubing from the top or cut off several inches of the outer tubing at the bottom until several inches of the inner tubing is exposed.
- 7. Unscrew the lower bladder adapter on the pump (refer to Geoprobe® Instruction Bulletin MK3022 or Technical Bulletin MK3013). Push the pump barbed fitting onto the sample tubing.

- 8. Again screw the pump onto the outer tubing. Screw the lower bladder adapter back into the pump. This step may be facilitated by temporarily lowering the tubing assembly into the well upside down, uncoiling it onto a clean surface, or uncoiling it into a clean section of well casing assembled on the surface.
- 9. Again deploy the pump and tubing into the well. Secure the top of the outer tubing at the top of the well casing using either the Outer Tubing Grip of a manual actuator or the Outer Tubing Adapter of an electric actuator.
- 10. Using the Hand Grip Assembly of a manual actuator or the mechanism of an electric actuator, cycle the inner tubing up and down to actuate the pump bladder. The tubing should be gently tensioned at the bottom of the stroke and pulled upward several inches each stroke.

6 Inertial Pump (Geoprobe® or Waterra®)

6.1 General

The inertial pump consist of a length of tubing with a check valve affixed to the lower end. It is a very simple device that is very effective at developing wells. As it is very difficult to produce low turbidity water with this pump due to the constant surging, it should generally not be used for sampling. The Geoprobe version of the pump can fit inside of the small diameter drive casing used for the installation of temporary screenpoint wells. The Waterra version of the valve can use an attached surge block pressed onto the valve to develop 2" dia. wells.

The inertial pump operates by manually or mechanically cycling the length of tubing and attached check valve up and down in the water column. The basic operation is as follows.

6.2 Operation

- 1. Affix a check valve to bottom of appropriate tubing by threading it onto the tubing. The valve will cut shallow threads into the tubing.
- 2. Lower the valve and tubing to the bottom of the well. Cut the tubing to an appropriate length to reach a bucket or other discharge location.
- 3. Either by hand or by attaching the tubing to a mechanical actuator, rapidly move tubing and check valve up and down in the water column. 4During each cycle, as the tubing is plunged downward in the water column, water will move upward through the check valve, past the ball check. On the upward stroke, the ball check will seat in the check valve, capturing water and moving it upward with the tubing.
- 5. For well development, cycle the valve in different portions of the screened interval. The inertial pump is also effective at vacuuming silt out of the bottom of the well.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

OF ERATING FROCEDURE						
Title: Field Equipment Cleaning and Decontamination						
Effective Date: December 18, 2015 Nu	mber: SESDPROC-205-R3					
Authors	3					
Name: Brian Striggow						
Title: Environmental Engineer						
Signature: 12-18-15						
Approvals						
Name: John Deatrick						
Title: Chief, Field Services Branch						
Signature: July Deathick Date	: 12/18/15					
Name: Hunter Johnson	se tamatla in every having a jobsol, de l'inicit etc. j					
Title: Field Quality Manager, Science and Ecosystem Support Division						
Signature: Date	: 12/18/15					

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-205-R3, Field Equipment Cleaning and Decontamination, replaces SESDPROC-205-R2.	December 18, 2015
Cover Page: The author was changed to Brian Striggow. SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Bobby Lewis to Hunter Johnson.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
General: Corrected any typographical, grammatical and/or editorial errors.	
Section 1.4: Differentiate between Liquinox® and Luminox® detergents.	
Section 3.4: Restore solvent rinse as alternative cleaning method.	
Section 3.7: Added section on cleaning of 12 Volt electric submersible pumps.	
Section 3.8: Added section on cleaning of bladder pumps.	
Section 3.9: Added language on cleaning and transport of SP15/16 screens	
Section 3.10: Added section on cleaning of rental pumps	
SESDPROC-205-R2, Field Equipment Cleaning and Decontamination, replaces SESDPROC-205-R1.	December 20, 2011
SESDPROC-205-R1, Field Equipment Cleaning and Decontamination, replaces SESDPROC-205-R0.	November 1, 2007
SESDPROC-205-R0, Field Equipment Cleaning and Decontamination, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	Ger	neral Information	4
	1.1	Purpose	4
	1.2	Scope/Application	4
	1.3	Documentation/Verification	4
	1.4	Definitions	4
	1.5	References	5
	1.6	General Precautions	6
	1.6.	1 Safety	6
	<i>1.6</i> .	2 Procedural Precaution	6
2	Int	roduction to Field Equipment Cleaning and Decontamination	7
	2.1	General	
	2.2	Handling Practices and Containers for Cleaning Solutions	7
	2.3	Disposal of Cleaning Solutions	
	2.4	Sample Collection Equipment Contaminated with Concentrated Materia	ıls8
	2.5	Sample Collection Equipment Contaminated with Environmental Media	
	2.6	Handling of Decontaminated Equipment	
3		d Equipment Decontamination Procedures	
	3.1	General	
	3.2	Specifications for Decontamination Pads	
	3.3	"Classical Parameter" Sampling Equipment	, 11
	3.4	Sampling Equipment used for the Collection of Trace Organic and	
		Inorganic Compounds	
	3.5	Well Sounders or Tapes	
	3.6	Redi-Flo2® Pump	
	<i>3.6.</i>		
	<i>3.6.</i>		
	<i>3.6.</i>		
	3.7	Mega-Monsoon® and GeoSub® Electric Submersible Pump	
	3.8	Bladder Pumps	
	3.9	Downhole Drilling Equipment	
	3.9.		
	3.9.	<i>y B 1</i>	
	3.9.	8	
	3.9.	<i>y</i> 8 1 1	. 16
	3.9.	y 85 \ 7	
		Equipment	
	3.10	Rental Pumps	. 18

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

1.2 Scope/Application

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the Field Equipment Center (FEC). On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on LAN and for maintaining records of review conducted prior to its issuance.

1.4 Definitions

- <u>Decontamination</u>: The process of cleaning dirty sampling equipment to the degree to which it can be re-used, with appropriate QA/QC, in the field.
- <u>Deionized water</u>: Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Deionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for deionized water.
- <u>Detergent</u> shall be a standard brand of phosphate-free laboratory detergent such as Liquinox® or Luminox®. Liquinox® is a traditional anionic laboratory detergent and is used for general cleaning and where there is

SESD Operating Procedure

Page 4 of 18

SESDPROC-205-R3

concern for the stability of the cleaned items in harsher cleaners. Luminox® is a specialized detergent with the capability of removing oils and organic contamination. It is used in lieu of a solvent rinse step in cleaning of equipment for trace contaminant sampling. Where not specified in these procedures, either detergent is acceptable.

- <u>Drilling Equipment</u>: All power equipment used to collect surface and sub-surface soil samples or install wells. For purposes of this procedure, direct push is also included in this definition.
- <u>Field Cleaning</u>: The process of cleaning dirty sampling equipment such that it can be returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.
- Organic-free water: Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.
- <u>Tap water</u>: Water from any potable water supply. Deionized water or organic-free water may be substituted for tap water.

1.5 References

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202. Most Recent Version

SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.6 General Precautions

1.6.1 Safety

Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.
- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

1.6.2 Procedural Precaution

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

2 Introduction to Field Equipment Cleaning and Decontamination

2.1 General

The procedures outlined in this document are intended for use by field investigators for cleaning and decontaminating sampling and other equipment in the field. These procedures should be followed in order that equipment is returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for the Data Quality Objectives (DQOs) of the study or investigation. If deviations from these procedures need to be made during the course of the field investigation, they will be documented in the field logbook along with a description of the circumstances requiring the use of the variant procedure.

Cleaning procedures for use at the Field Equipment Center (FEC) are found in SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

2.2 Handling Practices and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- <u>Detergent</u> must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.
- <u>Tap water</u> may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.
- <u>Deionized water</u> must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.
- Organic-free water must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

2.3 Disposal of Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW); including used wash water and rinse water are in SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202).

2.4 Sample Collection Equipment Contaminated with Concentrated Materials

Equipment used to collect samples of concentrated materials from investigation sites must be field cleaned before returning from the study. At a minimum, this should consist of washing with detergent and rinsing with tap water. When the above procedure cannot be followed, the following options are acceptable:

- 1. Leave with facility for proper disposal;
- 2. If possible, containerize, seal, and secure the equipment and leave on-site for later disposal;
- 3. Containerize, bag or seal the equipment so that no odor is detected and return to the SESD.

It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.5 Sample Collection Equipment Contaminated with Environmental Media

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

- 1. Wipe the equipment clean;
- 2. Water-rinse the equipment;
- 3. Wash the equipment in detergent and water followed by a tap water rinse.
- 4. For grossly contaminated equipment, the procedures set forth in Section 2.4 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the FEC without being field cleaned. If possible, FEC personnel should be notified that equipment will be returned without being field cleaned. It is the project leader's

responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.6 Handling of Decontaminated Equipment

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

3 Field Equipment Decontamination Procedures

3.1 General

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

3.2 Specifications for Decontamination Pads

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.
- The pad should not leak.
- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
- Water should be removed from the decontamination pad frequently.
- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

3.3 "Classical Parameter" Sampling Equipment

"Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 3.3 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

3.4 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

3.4.1 Standard SESD Method

- 1. An optional Liquinox® detergent wash step may be useful to remove gross dirt and soil.
- 2. Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films.
- 3. Rinse thoroughly with tap water.
- 4. Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to **a**ir-dry.
- 5. Wrap the dry equipment with aluminum foil or bag in clean plastic. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

3.4.2 Alternative Solvent Rinse Method

The historical solvent rinse method of cleaning equipment for trace contaminant sampling remains an acceptable method.

1. Clean with tap water and Liquinox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Liquinox® detergent and high pressure hot water) as an alternative to

SESD Operating Procedure

Page 11 of 18

SESDPROC-205-R3

brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

- 2. Rinse thoroughly with tap water.
- 3. Rinse thoroughly with deionized water.
- 4. Rinse with an appropriate solvent (generally isopropanol).
- 5. Rinse with organic-free water and place on a clean foil-wrapped surface to **a**irdry.
- 4. Wrap the dry equipment with aluminum foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused.

3.5 Well Sounders or Tapes

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

- 1. Wash with Liquinox® detergent and tap water.
- 2. Rinse with tap water.
- 3. Rinse with deionized water.

3.6 Redi-Flo2® Pump

CAUTION – Do not wet the controller. Always disconnect power from the pump when handling the pump body.

The Redi-Flo2® pump and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on whether the pump is used solely for purging or used for purging and sampling.

3.6.1 Purge Only (Pump and Wetted Portion of Tubing or Hose)

1. Disconnect power and wash exterior of pump and wetted portion of the power lead and tubing or hose with Liquinox® detergent and water solution.

SESD Operating Procedure

Page 12 of 18

SESDPROC-205-R3

- 2. Rinse with tap water.
- 3. Final rinse with deionized water.
- 4. Place pump and reel in a clean plastic bag and keep tubing or hose contained in clean plastic or galvanized tub between uses.

3.6.2 Purge And Sample

Grundfos Redi-Flo2® pumps are extensively decontaminated and tested at the FEC to prevent contamination from being transmitted between sites. The relevant sections of SESDPROC-206, *Field Equipment Cleaning and Decontamination at the FEC*, should be implemented in the field where a high risk of crosscontamination exists, such as where NAPL or high-concentration contaminants occur. In most cases, the abbreviated cleaning procedure described below will suffice, provided that sampling proceeds from least to most contaminated areas.

- 1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately (See Section 3.6.3 for check valve). Wash the pump exterior with detergent and water.
- 2. Prepare and fill three containers with decontamination solutions, consisting of Container #1, a tap water/detergent washing solution. Luminox® is commonly used. An additional pre-wash container of Liquinox® may be used; Container #2, a tap water rinsing solution; and Container #3, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution. An array of 2' long 2" PVC pipes with bottom caps is a common arrangement. The solutions should be changed at least daily.
- 3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.
- 4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.
- 5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.

- 6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.
- 7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.
- 8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.
- 9. Place the pump and reel in a clean plastic bag.

3.6.3 Redi-Flo2® Ball Check Valve

- 1. Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.
- 2. Using a brush, scrub all components with detergent and tap water.
- 3. Rinse with deionized water.
- 4. Rethread the ball check valve to the Redi-Flo2® pump head.

3.7 Mega-Monsoon® and GeoSub® Electric Submersible Pump

As these pumps have lower velocities in the turbine section and are easier to disassemble in the field than Grundfos pumps, the outer pump housing should be removed to expose the impeller for cleaning prior to use and between each use when used as a sampling pump for trace contaminant sampling.

- 1. Remove check valves and adapter fittings and clean separately.
- 2. Remove the outer motor housing by holding the top of the pump head and unscrewing the outer housing from its O-ring sealed seat.
- 3. Clean all pump components per the provisions of section 3.4. Use a small bottle brush for the pump head passages
- 4. Wet the O-ring(s) on the pump head with organic-free water. Reassemble the outer pump housing to the pump head.
- 5. Clean cable and reel per Section 3.4.
- 6. Conduct final rinse of pump with organic-free water over pump and through pump turbine.

3.8 Bladder Pumps

Bladder pumps are presumed to be intended for use as purge-and-sample pumps. The Geotech® bladder pump and Geoprobe Systems® mechanical bladder pump can be cleaned similarly.

- 1. Discard any tubing returned with the pump.
- 2. Completely disassemble the pump, being careful to note the initial position of and retain any springs and loose ball checks.
- 3. Discard pump bladder.
- 4. Clean all parts as per the standard cleaning procedure in Section 3.4.
- 5. Install a new Teflon® bladder and reassemble pump.

3.9 Downhole Drilling Equipment

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

3.9.1 Introduction

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 3.2 of this procedure.

Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam, with a detergent compartment, should be obtained.

3.9.2 Preliminary Cleaning and Inspection

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

SESD Operating Procedure

Page 15 of 18

SESDPROC-205-R3

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (detergent and high pressure hot water), or wire brushing. Sandblasting should be performed <u>prior to arrival</u> on site, or well away from the decontamination pad and areas to be sampled.
- Any portion of the drilling equipment that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.
- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can provide materials without the printing and/or writing if specified when ordered. Items that cannot be cleaned are not acceptable and should be discarded.
- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

3.9.3 Drill Rig Field Cleaning Procedure

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) between boreholes.

3.9.4 Field Decontamination Procedure for Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does <u>not</u> apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 3.4 of this procedure.

1. Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill

rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

- 2. Rinse thoroughly with tap water.
- 3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

3.9.5 Field Decontamination Procedure for Direct Push Technology (DPT) Equipment

- 1. Certain specific procedures for the decontamination of DPT tools are described in the various sampling procedures, but the following general guidelines apply:
- 2. Prior to return to the Field Equipment Center, all threaded tool joints should be broken apart and the equipment cleaned per the provisions of *Section 2.5, Sample Collection Equipment Contaminated with Environmental Media* of this procedure.
- 3. Equipment that contacts the sample media and is cleaned in the field for reuse should be cleaned per the provisions of *Section 3.4*, *Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds* of this procedure. This would include piston sampler points and shoes, screen point sampler screens and sheaths, and the drive rods when used for groundwater sampling.
- 4. Equipment that does not directly contact the sample media and is cleaned in the field for reuse can generally be cleaned per the provisions of Section 3.7.4, Field Decontamination Procedure for Drilling Equipment of this procedure.
- 5. Stainless steel SP15/16 well screens require special care as the narrow slots are difficult to clean under even controlled circumstances and galvanic corrosion can release chrome from the screen surface. As soon as possible after retrieval, the screen slots should be sprayed from the outside to break loose as much material as possible before it can dry in place. To prevent galvanic corrosion, the screens must be segregated from the sampler sheaths, drive rods, and other carbon steel during return transport from the field.

SESD Operating Procedure

3.10 Rental Pumps

Completing a groundwater sampling project may require the use of rental pumps. Rental pumps are acceptable where they are of suitable stainless steel and Teflon® construction. These pumps should be cleaned prior to use using the procedures specified herein and a rinse-blank collected prior to use.

Effective Date: December 18, 2015

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

	OPERATIN g, Marking, Labeli aste Samples		pping of Environmental
Effective Date:	February 4, 2015	Number	: SESDPROC-209-R3
	- 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	Authors	
Name: Art Master Title: Environm Signature:	ental Scientist, Regional I	Expert Date: 2 Approvals	14/2015
Signature:	eld Services Branch	Date: 2	12/15
Name: Hunter Jo Title: Field Qua	hnson llity Manager, Science an		upport Division

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-209-R3, Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, replaces SESDPROC-209-R2.	February 4, 2015
Cover Page: Changes made to reflect reorganization of SESD from two field branches to one: John Deatrick listed as the Chief, Field Services Branch. The FQM was changed from Liza Montalvo to Hunter Johnson.	
Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	
SESDPROC-209-R2, Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, replaces SESDPROC-209-R1.	April 20, 2011
SESDPROC-209-R1, Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, replaces SESDPROC-209-R0.	November 1, 2007
SESDPROC-209-R0, Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, Original Issue	February 05, 2007

Effective Date: February 4, 2015

TABLE OF CONTENTS

1	Gei	neral Information	4
	1.1	Purpose	4
-	1.2	Scope/Application	
-	1.3	Documentation/Verification	4
-	1.4	References	5
	1.5	General Precautions	5
	1.5.	.1 Safety	5
2	Shi	pment of Dangerous Goods	6
3	Shi	pment of Environmental Samples	7

1 General Information

1.1 Purpose

Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by Department of Transportation under 49 CFR, Subchapter C, Hazardous Materials Regulations, and the International Air Transport Authority (IATA), which is equivalent to United Nations International Civil Aviation Organization (UN/ICAO). Transportation of hazardous materials (dangerous goods) by EPA personnel is covered by EPA Order 1000. This document describes general and specific procedures, methods and considerations to be used and observed by SESD field investigators when packing, marking, labeling and shipping environmental and waste samples to ensure that all shipments are in compliance with the above regulations and guidance.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when packing, marking, labeling, and shipping environmental samples and dangerous goods by air transport. Samples collected during field investigations or in response to a hazardous materials incident must be classified prior to shipment, as either environmental or hazardous materials (dangerous goods) samples.

In general, environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with high levels of hazardous materials. Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods.

Government employees transporting samples or hazardous materials (i.e., preservatives or waste samples) in government vehicles are not subject to the requirements of this section in accordance with 49 CFR 171.1(d)(5). EPA contractors, however, are not covered by this exemption and may not transport these materials without full compliance with 49 CFR.

Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

SESD Operating Procedure

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version.

Title 40 Code of Federal Regulations (CFR), Pt. 136.3, Identification of Test Procedures, July 1, 2001. See Table II, Footnote 3.

Title 49 CFR, Pt. 171.1(d)(5), Applicability of Hazardous Materials Regulations (HMR) to Persons and Functions.

United States Department of Transportation (US DOT). 2003. Letter from Edward T. Mazzullo, Director, Office of Hazardous Materials Standards, to Henry L. Longest II, Acting Assistant Administrator, USEPA, Ref No. 02-0093, February 13, 2003.

US Environmental Protection Agency (US EPA) Order 1000.18, February 16, 1979.

US EPA. 1981. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), April 13, 1981.

US EPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA.

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version.

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version.

1.5 General Precautions

1.5.1 *Safety*

Proper safety precautions must be observed when packing, marking, labeling, and shipping environmental or waste samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional.

2 Shipment of Dangerous Goods

The project leader is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, IATA, then that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for that material. If the composition of the collected sample(s) is unknown, and the project leader knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of the waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport.

In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., NaOH pellets, HCL, etc.) which are designated as dangerous goods by IATA is regulated. Shipment of nitric acid is strictly regulated. Consult the IATA Dangerous Goods Regulations for guidance. Dangerous goods must not be offered for air transport by any personnel except SESD's dangerous goods shipment designee or other personnel trained and certified by IATA in dangerous goods shipment.

3 Shipment of Environmental Samples

Guidance for the shipment of environmental laboratory samples by personnel is provided in a memorandum dated March 6, 1981, subject "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Laboratory Samples". By this memorandum, the shipment of the following <u>unpreserved</u> samples is not regulated:

- Drinking water
- Treated effluent
- Biological specimens
- Sediment
- Water treatment plant sludge
- POTW sludge

In addition, the shipment of the following <u>preserved</u> samples is not regulated, provided the amount of preservative used does not exceed the amounts found in 40 CFR 136.3 or the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version. This provision is also discussed in correspondence between DOT and EPA (Department of Transportation, Letter from Edward T. Mazzullo, Director, Office of Hazardous Materials Standards, to Henry L. Longest II, Acting Assistant Administrator, USEPA, Ref No.: 02-0093, February 13, 2003). It is the shippers' (individual signing the air waybill) responsibility to ensure that proper amounts of preservative are used:

- Drinking water
- Ambient water
- Treated effluent
- Biological specimens
- Sediment
- Wastewater treatment plant sludge
- Water treatment plant sludge

Samples determined by the project leader to be in these categories are to be shipped using the following protocol, developed jointly between USEPA, OSHA, and DOT. This procedure is documented in the "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Untreated wastewater and sludge from Publicly Owned Treatment Works (POTWs) are considered to be "diagnostic specimens" (not environmental laboratory samples). However, because they are not considered to be etiologic agents (infectious) they are not restricted and may be shipped using the procedures outlined below.

Environmental samples should be packed prior to shipment by air using the following procedures:

- 1. Allow sufficient headspace (ullage) in all bottles (except VOA containers with a septum seal) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).
- 2. Ensure that the lids on all bottles are tight (will not leak).
- 3. Place bottles in separate and appropriately sized polyethylene bags and seal the bags. If available, the use of Whirl-Pak bags is preferable, if unavailable seal regular bags with tape (plastic electrical tape).
- 4. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape inside and outside. Line the cooler with a large heavy duty plastic bag.
- 5. Place cushioning/absorbent material in the bottom of the cooler and then place the containers in the cooler with sufficient space to allow for the addition of cushioning between the containers.
- 6. Put "blue ice" (or ice that has been "double bagged" in heavy duty polyethylene bags and properly sealed) on top of and/or between the containers. Fill all remaining space between the containers with absorbent material.
- 7. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).
- 8. Place the Chain-of-Custody Record or the CLP Traffic Report Form (if applicable) into a plastic bag, and tape the bag to the inner side of the cooler lid.
- 9. Close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: Groundwater Sampling	
Effective Date: April 26, 2017	Number: SESDPROC-301-R4
Authors	
Name: Brian Striggow	9
Title: Environmental Engineer	
Signature:	Date: 4-20-17
Approvals	
Name: John Deatrick	
Title: Chief, Field Services Branch	
Signature: John Deatrick	Date: 4/24/17
Name: Hunter Johnson	
Title: Field Quality Manager, Science and Eco	osystem Support Division
Signature:	Date: 4/20/17

Effective Date: April 26, 2017

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-301-R4, Groundwater Sampling, replaces SESDPROC-301-R3.	April 26, 2017
General: Corrected any typographical, grammatical, and/or editorial errors.	
General: An extensive rewrite and reorganization of material. Stronger support of low-flow methods while maintaining cautious view of minimal/no purge methods.	
SESDPROC-301-R3, Groundwater Sampling, replaces SESDPROC-301-R2.	March 6, 2013
SESDPROC-301-R2, Groundwater Sampling, replaces SESDPROC-301-R1.	October 28, 2011
SESDPROC-301-R1, Groundwater Sampling, replaces SESDPROC-301-R0.	November 1, 2007
SESDPROC-301-R0, Groundwater Sampling, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	GENERAL INFORMATION	5
1.1	Purpose	5
1.2	Scope/Application	
1.3	Documentation/Verification	
1.4	References	5
1.5	General Precautions	
	5.1 Safety	
	5.2 Procedural Precautions	
		0
2	SPECIAL SAMPLING CONSIDERATIONS	9
2.1	Volatile Organic Compounds (VOC) Analysis	9
2.2	Special Precautions for Trace Contaminant Groundwater Sampling	9
2.3	Sample Handling and Preservation Requirements	
2.4	Quality Control	
2.5	Records	
3	GROUNDWATER PURGING AND SAMPLING	12
3.1	Overview of Purging and Sampling Strategies	12
3.2	Purging	
	Parameter Stabilization Criteria	
	Multiple-Volume Purge	
	4.1 Purge Volume Determination	
	4.2 Pumping Conditions	
	4.3 Stability of Chemical Parameters	
	4.4 Sample Collection	
	Low-Flow Method	
	5.1 Nomenclature	
	5.2 Placement of Pump Tubing or Intake	
	5.3 Conditions of Pumping	
	5.4 Stability of Chemical Parameters	
	5.5 Sample Collection	
	Minimum-Purge and No-Purge Sampling	
	6.1 Minimum Purge Sampling	
	6.2 Passive Diffusion Bags	
	6.3 HydraSleevesTM	
	6.4 Snap Samplers	
	Equipment Considerations	
	7.1 Use of Peristaltic Pumps	
	7.2 Use of Submersible Centrifugal Pumps	
	7.3 Use of Bailers	
	7.4 Use of Bladder Pumps	
	7.5 Use of Inertial Pumps	
- •	v 1	_

3.8	Wells With In-Place Plumbing	27
3	8.8.1 Continuously Running Pumps	27
	3.8.2 Intermittently or Infrequently Running Pumps	
	Temporary Monitoring Wells	
	3.9.1 General Considerations	
3	3.9.2 Development of Temporary Wells	28
	3.9.3 Decommissioning of Temporary Wells	
	3.9.4 Other Considerations for Direct-Push Groundwater Sampling	
3.10	0 Wells Purged to Dryness	30
4	ADDITIONAL PURGING AND SAMPLING CONSIDERATIONS	31
4.1	Field Care of Purging Equipment	31
4.2	Investigation Derived Waste	31
4.3	Sample Preservation	31
4.4	Special Sample Collection Procedures	31
4	4.4.1 Trace Organic Compounds and Metals	31
4	1.4.2 Order of Sampling with Respect to Analytes	32
4.5	Filtering	32
4.6	Bacterial Sampling	33
4.7	Specific Sampling Equipment Quality Assurance Techniques	34
4.8	Auxiliary Data Collection	34
4.9	Well Development	34

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting groundwater samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion that SESD field personnel determine that any of the procedures described are either inappropriate, inadequate or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

Interstate Technology & Regulatory Council, <u>Technology Overview of Passive Sampler Technologies</u>, Prepared by The Interstate Technology & Regulatory Council Diffusion Sampler Team, March 2006.

Nielsen, David. Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring. 2nd ed. Boca Raton, FL: Taylor&Francis, 2006. Print.

Puls, Robert W., and Michael J. Barcelona. 1989. <u>Filtration of Ground Water Samples for</u> Metals Analysis. Hazardous Waste and Hazardous Materials 6(4), pp.385-393.

Puls, Robert W., Don A. Clark, and Bert Bledsoe. 1992. <u>Metals in Ground Water:</u> <u>Sampling Artifacts and Reproducibility</u>. Hazardous Waste and Hazardous Materials 9(2), pp. 149-162.

SESD Guidance Document, Design and Installation of Monitoring Wells, SESDGUID-001, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Groundwater Level and Well Depth Measurement, SESDPROC-105, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDROC-202, Most Recent Version

SESD Operating Procedure for Pump Operation, SESDPROC-203, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Potable Water Supply Sampling, SESDPROC-305, Most Recent Version

United States Environmental Protection Agency (US EPA). 1975. <u>Handbook for Evaluating Water Bacteriological Laboratories</u>. Office of Research and Development (ORD), Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1977. <u>Sampling for Organic Chemicals and Microorganisms in the Subsurface</u>. EPA-600/2-77/176.

US EPA. 1978. <u>Microbiological Methods for Monitoring the Environment, Water and Wastes</u>. ORD, Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1981. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), April 13, 1981.

US EPA. 1995. <u>Ground Water Sampling - A Workshop Summary</u>. Proceedings from the Dallas, Texas November 30 – December 2, 1993 Workshop. ORD, Robert S. Kerr Environmental Research Laboratory. EPA/600/R-94/205, January 1995.

US EPA 1996. Ground Water Issue. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. ORD, Robert W. Puls and Micael Barcelona. EPA/540/S-95/504, April 1996

US EPA. Analytical Services Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

Varljen, M., Barcelona, M., Obereiner, J., & Kaminski, D. (2006). Numerical simulations to assess the monitoring zone achieved during low-flow purging and sampling. *Ground Water Monitoring and Remediation*, 26(1), 44-52.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns

and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done legibly, completely, and neatly in a bound logbook.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Groundwater samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either pre-preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas unpreserved samples have only a seven-day holding time. In the majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high amount of dissolved limestone, i.e., is highly calcareous, there will likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles and rendering the sample unacceptable. In this case, unpreserved vials should be used and arrangements confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm or knuckle to check if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. While the 8260 method allows for bubbles up to 6 mm at the time of analysis, dissolved or entrained gases can coalesce during shipment. Collecting VOC vials absent of bubbles is generally feasible and is a reasonable precaution.

2.2 Special Precautions for Trace Contaminant Groundwater Sampling

- Sampling equipment must be constructed of Teflon® or stainless steel materials. Bailers and pumps should be of Teflon® and stainless steel construction throughout.
- New Teflon® tubing should be used at each well, although tubing dedicated to a
 particular well may be reused, either after decontamination or storage in the well
 between sampling events. Caution is appropriate in reusing tubing where early
 sampling events report high concentrations of contaminants.
- A clean pair of new, non-powdered, disposable gloves will be worn each time a
 different location is sampled and the gloves should be donned immediately prior to
 sampling. The gloves should not come in contact with the media being sampled and
 should be changed any time during sample collection when their cleanliness is
 compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

- Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if purging and sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same cooler as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, verified certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

- 1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.
- 2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.
- 3. Place the sample into appropriate, labeled containers. Samples collected for VOC, and alkalinity analysis must be collected without headspace. All other sample containers must be filled with an allowance for ullage.
- 4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If pre-preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by Analytical Services Branch (ASB) personnel prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), most recent version.

5. Sample containers should be placed in an ice-filled cooler as soon as possible after filling. Ice in coolers should be in bags with minimal pooled water and the cooler should be periodically checked and replenished to maintain sample storage temperature.

2.4 Quality Control

Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers, tubing, or other sampling equipment.

Where appropriate, a background sample upgradient of all known influences or a control sample upgradient of site influences may be indicated. Background and control samples should be collected as close to the sampled area as possible and from the same water-bearing formation as the site samples.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Procedure for Sample and Evidence Management, SESDPROC-005.

3.1 Overview of Purging and Sampling Strategies

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of aquifer conditions. Sampling is the process of obtaining, containerizing, and preserving (when required) a ground water sample after the purging process is complete. There are several approaches to well purging and sampling that may be appropriate in various circumstances or for various combinations of available equipment. They are briefly summarized below and in *Table 1, Purge and Sample Strategies with Equipment Considerations*.

The **Multiple-Volume Purge** method involves removing a minimum of three well volumes of water from the top of the water column and then sampling when the well has achieved stability of water quality parameters and adequately low turbidity. This is a traditional method and consistent results are generally obtained with samplers of varying skill. A drawback is that large volumes of purge water may be produced for large diameter or deep wells.

The **Low-Flow** method involves purging the well at a relatively low flow rate that minimizes drawdown, with the pump or tubing inlet located within the screened interval of the well. The well is sampled when water quality parameters are stable, adequately low turbidity is achieved, and the water level has achieved a stable drawdown (an unchanging water level). This method is often faster than Multiple-Volume Purge and generates less purge water. The method requires more skill and judgment on the part of the samplers.

The **Multiple-Volume Purge** method and the **Low-Flow** method can be considered equivalent for conventionally screened and filter-packed wells in that they both sample a flow-weighted average of water entering the well during pumping. However, other variables can result in differences between results with the two methods. In repeat sampling events, the sampling design should not change from one method to the other without appropriate cause. The transition should be noted in the report.

Minimum-Purge and No-Purge methods are based on the assumption that water within the screened interval of the well is at equilibrium with the water in the surrounding aquifer. This assumption should be carefully considered in the use of these methods and various cautions are discussed in sections below. The minimal-purge and no-purge methods are most useful for long-term monitoring and are generally inappropriate for the early stages of investigation. In some cases the methods might be used to gather screening-level data from wells that are too large to practically purge or have other sampling complications.

The **Minimum-Purge** and **No-Purge** methods collect water in the vicinity of the device under near-static conditions and are not equivalent to the multiple-volume purge and Low-Flow methods. Stratification of horizontal flow or vertical flow conditions within the well can result in non-intuitive and deceptive results. A comparison study should be conducted before transitioning a sampling program to the minimal-purge or no-purge methods.

3.2 Purging

Wells are purged to eliminate stagnant water residing in the casing and/or screen that has undergone geochemical changes or loss of VOCs. At the conclusion of purging, the desired flow-weighted average of water entering the well under pumping conditions will be available for sampling. Turbidity is often elevated during purging by the disturbance of formation materials at the borehole walls. As many contaminants (metals and many organics) will sorb to the formation particles, a sample including these particles will not represent the dissolved concentrations of the contaminants. Thus, a secondary goal of purging is to reduce the turbidity to the point that the sample will represent the dissolved concentration of contaminants.

In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed and the volume of water removed during purging. The measurements should be recorded in a purge table in the field logbook that includes the start time of purging, the parameter measurements at intervals during purging, estimated pumped volumes, depths to water for Low-Flow sampling, and any notes of unusual conditions. A typical purge table used for Low-Flow sampling is reproduced below.

	pН	Spec. Cond.	Temp.	D.O.	D.O.	ORP	Turbidity	Water Level	Purge Vol.
TIME	(S.U.s)	(us/cm)	(Deg. C)	(mg/L)	(% sat.)	(mV)	(NTUs)	(Ft.)	(gallons
0930								Pump On	
0935	5.71	1065	19.6	0.77	8.7	43.9	210	24.83	1/4
1004	5.64	988	20.0	0.36	3.9	2225	17.8	25.24	Ź
1026	5.63	959	20.5	0.25	2.7	98	9.95	25.18	3/2
1038	5,62	950	20,5	0.21	2.4	75	9.85	25,18	4 .
046	5.61	946	20.8	0.21	2.4	73	6.07	25,18	41/2
						-	-		
1047			1					Sample Co	llection

3.3 Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Secondary Drinking Water Standard of 5 NTUs).

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than 5 percent. Other parameters, such as dissolved oxygen (DO) or oxidation-reduction potential (ORP), may also be used as a purge adequacy parameter. Normal stability goals for DO are 0.2 mg/L or 10% change in saturation, whichever is greater. DO and ORP measurements must be conducted using either a flow-through cell or an over-topping cell to minimize oxygenation of the sample during measurement. A reasonable ORP stability goal is a range of 20 mV, although ORP is rarely at equilibrium in environmental media and often will not demonstrate enough stability to be used as a purge stabilization parameter. Determining the frequency of measurements has generally been left to 'Best Professional Judgement'. Care is in order, as measurements recorded at frequent intervals with low flow rates can falsely indicate stability of parameters. Several measurements should be made early in the well purge to establish the direction and magnitude of trends, which can then inform the stability decision. Stability parameters should either be not trending, or approaching an asymptote, when a stability determination is made. As a matter of practice, parameter measurements are generally made at 5-10 minute intervals.

Because the measured groundwater temperature during purging is subject to changes related to surface ambient conditions and pumping rates, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from SESD's list of parameters used for stability determination. Even though temperature is not used to determine stability, it is still advisable to record the temperature of purge water as it is often used in the interpretation of other parameters.

Information on conducting the stability parameter measurements is available in the SESD Operating Procedures for Field pH Measurement (SESDPROC-100), Field Specific Conductance Measurement (SESDPROC-101), Field Temperature Measurement (SESDPROC-102), Field Turbidity Measurement (SESDPROC-103), Field Measurement of Dissolved Oxygen (SESDPROC-106) and Field Measurement of Oxidation-Reduction Potential (SESDPROC-113).

Table 1, Purge and Sample Strategies with Equipment Considerations

Purging Strategy	Purge Eqpt	Sample Eqpt	Comments
Multi-Volume Purge			Overall Method Comments- Advantages: Consistent results can be achieved with minimal skill level required. Common, simple equipment can be used. Disadvantages: Can result in large volumes of purge water. Can take extended periods of time with large diameter wells or long water columns.
In this traditional method, 3-5 well volumes of water are	Bailer	Bailer	Bailers are rarely used for purging due to the effort required, the difficulty of lowering turbidity adequately, and the possibility of aerating the upper water column.
removed from the top of the water column while verifying the stability of water quality parameters.	Electric Submersible Pump	Bailer	Common multiple-volume setup when depth to water exceeds 25 feet. Abbreviated pump decontamination procedure can be used between wells.
Following the well purge, the well is sampled from the top of the water column.	Electric Submersible Pump	Electric Submersible Pump	Requires full pump decontamination and new tubing at each well. In most cases the pump would be deployed to the screened interval instead to perform Low-Flow sampling.
	Peristaltic Pump	Peristaltic Pump	Common, multi-volume setup when depth to water is less than 25 feet. Special sampling techniques are required for the collection of SVOCs and VOCs.
Low-Flow methods			Overall Method Comments- Advantages: Lower volumes of purge water. May be faster, especially with longer water columns. Disadvantages: Requires greater skill for consistent results. Higher tubing costs than multi-volume method.
The pump or tubing inlet is placed within the screened	Electric Submersible Pump	Electric Submersible Pump	Commonly used when depth to water exceeds 25 feet. Pump is cleaned to sample equipment standards prior to sampling each well and new or dedicated tubing used for each well. Concerns have been raised concerning VOC loss from agitation in the turbine section or from sample heating.
interval and the well is purged to stable water quality parameters while maintaining stable drawdown of the water level.	Peristaltic Pump	Peristaltic Pump	Commonly used where depth to water is less than 25 feet. Special sampling techniques required for the collection of SVOCs and VOCs. Concerns have been raised concerning VOC loss from vacuum created in sample tubing.
	Bladder Pump	Bladder Pump	Least danger of VOC loss as entire sample train is under positive pressure and little sample heating occurs. Difficult to remove large volumes of water in reasonable time. Mild surging effect may keep turbidity elevated in sensitive wells.
Minimum-Purge, No-Purge Methods			Overall Method Comments- Advantages: Very little or no waste water. Well suited to repeat sampling events. Likely faster with lower costs. Disadvantages: Not directly equivalent to other methods. Vertical stratification or vertical flow conditions in the screened interval can result in deceptive or non-intuitive analytical results.
	Pumps, various	Pumps, various	In the minimum-purge method, the internal volume of the sample tubing and pump is calculated. One volume of the pump and tubing is purged to flush the equipment and the well is then sampled.
Predicated on the assumption that aquifer flow through the well maintains the water in the screened interval in a state equivalent to that in the aquifer. This	na	Passive Diffusion Bags	In most common form, a sealed water-filled polyethylene bag is allowed to equilibrate in the water column. Suitable primarily for VOCs. Generally require 2 week minimum in-situ residence time.
assumption should be proven or the data qualified. Sampling is conducted with little or no purge, or by	na	Hydrasleeves	Collect a fixed volume of water from a specific interval. Requires duplicate samplers or redeployment for larger volumes. Sorbtion issues may bias results.
equilibrating a sampler in screened interval.	na	Snap sampler	Deploys a sample container in the sampling interval where it is allowed to equilibrate (commonly for two weeks) before being sealed insitu by the sampler mechanism and retrieved. Limited to specific containers.

SESD Operating Procedure

Page 15 of 34

SESDPROC-301-R4

Groundwater Sampling

Groundwater Sampling(301)_AF.R4

3.4 Multiple-Volume Purge

In the traditional Multiple-Volume Purge method, water is removed from the top of the water column, causing water to enter the screen and flush stagnant casing water upward to be subsequently removed. In recognition of the mixing of fresh and stagnant water in the casing section, a minimum of three well volumes is removed, at which time purging can be terminated upon parameter stabilization. Wells can be assumed to be adequately purged when five well volumes have been removed, although further purging may be conducted to meet specific goals, such as further reduction of turbidity.

3.4.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined The diameter of the well is determined and the water level and total depth of the well measured and recorded prior to inserting a pump or tubing into the well. The water level is subtracted from the total depth, providing the length of the water column. Specific methodology for obtaining these measurements is found in SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105).

Once this information is obtained, the volume of water to be purged can be determined using one of several methods. The well volume can be calculated using the equation:

$$V = 0.041 d^2h$$

Where:

h = length of water column in feet

d = diameter of well in inches

V =one well volume in gallons

Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, such as *Table 2 Well Casing Diameter Volume Factors*. The water column length is multiplied by the appropriate factor in the Table 2 to determine the single well volume, three well volumes, or five well volumes for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

TABLE 2, WELL CASING DIAMETER VOLUME FACTORS

			Minimum	Maximum
		Reference	purge	purge*
		1 Well	3 Well	5 Well
		Volume	Volumes	Volumes
		(gallons/ft)	(gallons/ft)	(gallons/ft)
	0.5	0.01	0.03	0.05
	0.75	0.02	0.07	0.11
	1	0.04	0.12	0.20
	2	0.16	0.49	0.82
	3	0.37	1.1	1.8
	4	0.65	2.0	3.3
	5	1.0	3.1	5.1
	6	1.5	4.4	7.3
	7	2.0	6.0	10.0
	8	2.6	7.8	13.1
	9	3.3	9.9	16.5
	10	4.1	12.2	20.4
(u	11	4.9	14.8	24.7
er (i	12 5.9		17.6	29.4
net	13	6.9	20.7	34.5
Diar	14	8.0	24.0	40.0
] Bu	15	9.2	27.5	45.9
Sasi	16	10.4	31.3	52.2
Well Casing Diameter (in)	18	13.2	39.7	66.1
Š	24	23.5	70.5	118
	36	52.9	159	264
	48	94.0	282	470

^{*} See text for discussion on terminating purge at five well volumes

An adequate purge is normally achieved when three to five well volumes have been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate multiplication of that volume, i.e., a minimum three well volumes, clearly identified as an initial purge volume goal.

3.4.2 Pumping Conditions

The pump or tubing inlet should be located at the top of the water column. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is as close as possible to the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump or tubing will have to be lowered to accommodate the drawdown.

3.4.3 Stability of Chemical Parameters

In the multiple-volume purge method, a stability determination may be made after three well volumes have been removed. If the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to a total of five well volumes) should be removed. If the parameters have not stabilized after the removal of five well volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible.

3.4.4 Sample Collection

There are several means by which sampling can proceed after adequate volume has been purged and water quality parameters have stabilized. If a submersible pump and tubing are of suitable material and cleanliness for sample collection, sampling can proceed immediately by directly filling bottles from the tubing outlet. Commonly with the multiple-volume purge method, the pump is set up and cleaned in a manner suitable only for purging. In these cases, the pump is stopped and removed from the well and sampling proceeds with a bailer per the procedure described in Section 3.6.3. The pump should have a check valve to prevent water in the pump tubing from discharging back into the well when the pump is stopped. If a peristaltic pump is used, sampling can proceed as described in Section 3.6.1.

3.5 Low-Flow Method

This method involves placing the pump or tubing inlet within the screened interval of the well and purging at a low enough rate to achieve stable drawdown and minimal depression of the water level. The well is sampled without interruption after field parameters are stable and low turbidity is achieved. In general, only water in the screened interval of the well is pumped and the stagnant water in the well casing above the screen is not removed. Wells can generally be sampled in less time with less purge volume than with the multi-volume purge method. More attention is required in the assessment of stability criteria than the multi-volume method.

3.5.1 Nomenclature

A variety of terminology has been used to describe this method by SESD and others, including: 'low flow', 'low-flow/low-volume', 'tubing-in-screen method', 'low flow/minimal drawdown', and 'micropurge'. The current preferred SESD terminology for this method is 'Low-Flow'. As the term 'micropurge' is sometimes used to refer to minimal-purge methods and has been trademarked by a vendor, the use of 'micropurge' to describe the Low-Flow method generally introduces ambiguity and confusion and thus the use of the term is discouraged.

3.5.2 Placement of Pump Tubing or Intake

The inlet of the pump tubing or intake of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. While it is often thought that particular aquifer zones can be targeted by specific pump or intake placement, for conventionally constructed screened and filter-packed monitoring wells the zone monitored is only weakly dependent on the intake placement (Varljen, Barcelona, Obereiner & Kaminski, 2006).

The pump or tubing can be placed by carefully lowering them to the bottom of the well and then withdrawing half of the screen length, plus the length of any sump sections at the bottom of the well. A drawback of this approach is that it may stir up sediment at the well bottom. An alternate approach is to lower the pump or tubing a measured distance to place it at mid-screen without touching the bottom of the well. In the case of pumps, special care should be used in lowering them slowly, especially in the screened interval, to prevent elevating turbidity needlessly by the surging action of the pump.

3.5.3 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well to measure the water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. In some cases, it will be necessary for the well to drawdown a considerable distance (10 ft or more in extreme cases) to maintain a minimal usable pumping rate for sampling (100-200 ml/min). Excessive pump rates and drawdown can result in increased turbidity, or aeration of the sample if the screen is exposed. Stable drawdown is an essential condition of the Low-Flow method. If the stable drawdown condition cannot be met, then one of the other methods should be employed.

3.5.4 Stability of Chemical Parameters

As with the Multiple-Volume Purging method described, it is important that all chemical parameters be stable prior to sampling. It is common for wells to require the removal of one of more screened-interval volumes (~2 gal for a 10 ft screen in a 2" dia. well) to achieve stability. Although it is possible for wells to achieve stability with lower purge volumes, the sampler should exercise caution in making an early stability determination.

3.5.5 Sample Collection

Low-Flow sampling is implemented using a pump and tubing suitable for sampling. After making the determination of parameter stability with stable drawdown, sampling can proceed immediately. Where submersible or bladder pumps are used, sampling can proceed by directly filling bottles from the tubing outlet. Where peristaltic pumps are used, sampling can proceed per the procedure described in Section 3.6.3.

3.6 Minimum-Purge and No-Purge Sampling

The Minimum-Purge and No-Purge sampling methods are employed when it is necessary to keep purge volumes to an absolute minimum, where it is desirable to reduce long-term monitoring costs, or where large wells or other limitations prevent well purging. The underlying assumption when employing these methods is that the water within the well screen is equilibrated with the groundwater in the associated formation. This assumption should be demonstrated prior to use of these methods or the results suitably qualified. These methods are generally impractical for SESD to implement because of the common lack of hydrogeological information in early investigative phases and the necessity with some methods that the samplers be pre-deployed to allow equilibration.

Vertical flow conditions and stratification of the water column have also been known to result in deceptive and non-intuitive analytical results. The use of these methods in the early phases of investigation can easily result in misinterpretation of site conditions and plume boundaries.

Particular caution is in order in the use of these methods when any of the following conditions exist:

- Low hydraulic conductivity (K<10⁻⁵ cm/sec)
- Low groundwater surface gradients
- Fractured bedrock
- Wells with long screened intervals
- Wells screened in materials of varying hydraulic conductivities

If it is desired to transition a long-term monitoring program to Minimum-Purge or No-Purge sampling, a pilot study should be conducted where the Minimum-Purge or No-Purge sample results are compared to the conventional methods in use. Multiple samplers may be deployed in the screened interval to help establish appropriate monitoring intervals.

These methods are in common use and for the purposes of the SESD quality system they can be considered standard, but unaccredited, procedures. Several Minimum-Purge or No-Purge procedures that might be employed are shown below. It is not the intention to recommend particular equipment or vendors, and other equipment that can accomplish the same goals may be suitable.

3.6.1 Minimum Purge Sampling

The pump or tubing inlet is deployed in the screened interval. A volume of water equal to the internal pump and tubing volume is pumped to flush the equipment. Sampling then proceeds immediately. While superficially similar to Low-Flow sampling, the results obtained in this method will be sensitive to the vertical pump or tubing inlet placement and are subject to the limitations described above.

3.6.2 Passive Diffusion Bags

The no-purge Passive Diffusion Bag (PDB) typically consists of a sealed low-density polyethylene (LDPE) bag containing deionized water. They are deployed in the screened interval of a well and allowed to equilibrate, commonly for two weeks, prior to retrieval and decanting of the water into sample containers. Many volatile organic compounds will reach equilibrium across the LDPE material, including BTEX compounds and many chlorinated solvents. Compounds showing poor equilibration across LDPE include acetone, MTBE, MIBK, and styrene. PDBs have been constructed of other materials for sampling other analytes, but the vast majority of PDB samplers are of the LDPE material. Various vendors and the Interstate Technology and Regulatory Council (ITRC) can provide additional information on these devices.

3.6.3 HydraSleevesTM

HydraSleeevesTM are no-purge grab sampling devices consisting of a closed-bottom sleeve of low-density polyethylene with a reed valve at the top. They are deployed in a collapsed state to the desired interval and fill themselves through the reed valve when pulled upward through the sampling interval. The following is a summary of their operation:

Sampler placement – A reusable weight is attached to the bottom of the sampler or the sampler is clipped to a weighted line. The HydraSleeveTM is lowered on the weighted line and placed with the top of the sampler at the bottom of the desired sampling interval. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. The well is allowed to return to equilibrium.

Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level and only minimal agitation during collection.

Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field parameter measurements.

Because the $HydraSleeve^{TM}$ is retrieved before equilibration can occur and they are constructed of non-Teflon® materials, there may be issues with sorbtion of contaminants in the use of this sampler.

3.6.4 Snap Samplers

The Snap Sampler is a patented no-purge groundwater sampling device that employs a double-end-opening bottle with "Snap" sealing end caps. The dedicated, device is deployed at the desired position in the screened interval with up to six Snap Samplers and six individual sampling bottles. The device is allowed to equilibrate in the screened interval and retrieved between 3 and 14 days after deployment. Longer deployments are possible to accommodate sampling schedules.

To operate, Snap Samplers are loaded with Snap Sampler bottles and the "Snap" caps are set into an open position. Samplers are deployed downhole with an attachment/trigger line and left to equilibrate downhole. To collect samples, the Snap Sampler bottles seal under the water surface by pulling a mechanical trigger line, or using an electric or pneumatic trigger system. The trigger releases Teflon® "Snap Caps" that seal the double-ended bottles. The end caps are designed to seal the water sample within the bottles with no headspace vapor. After the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal.

The manufacturer of the Snap Sampler provides considerable additional information on the validation and use of the device.

3.7 Equipment Considerations

Equipment choices are dictated by the purging and sampling method used, the depth to water, the quantity of water to be pumped, and quality considerations. The advantages and disadvantages of various commonly used pumps are discussed in the sections below and summarized in *Table 1, Purge and Sample Strategies with Equipment Considerations*. Additional information on the use of individual pumps is available in SESD Operating Procedure for Pump Operation, SESDPROC-203.

3.7.1 Use of Peristaltic Pumps

Peristaltic pumps are simple, inexpensive, and reliable equipment for purging and sampling where the limit of suction is not exceeded (approximately 25-30 vertical feet from the groundwater surface to the pump). When used for sampling, they should be equipped with new Teflon® tubing for each well. The flexible peristaltic pump-head tubing should also be changed between wells.

Samples for organic analyses cannot be exposed to the flexible peristaltic pump-head tubing, both due to the risk that the tubing would sorb contaminants and the propensity of this tubing to contribute organic compounds to the sample. Samples can be collected without contact with the pump-head tubing by the use of vacuum transfer caps for

analyses requiring 1 liter glass containers and the use of the 'soda-straw' method for the filling of VOC vials.

The sample containers for the more turbidity-sensitive analyses are filled first, as filling the VOC vials (and to a lesser extent the glass bottles) may disturb the well and increase turbidity. The most appropriate order of sampling with a peristaltic pump is generally to fill poly containers for metals and classical analyses, followed by glass bottles for SVOCs and associated analyses, and finally to fill 40 ml VOC vials.

The following step-by-step procedure assumes that the pump has been set up per SESD Operating Procedure for Pump Operation (SESDPROC-203) and that containers for a typical full suite of analyses will be filled. The procedure is suitable for use with either multi-volume Purge and Low-Flow methods with minor differences in the collection of VOCs:

- 1. Deploy the lower end of the tubing to the desired point in the well. This would be the top-of-water for the multi-volume purge method or to the mid-screen for the Low-Flow method. Connect the well tubing to the flexible pump-head tubing and connect a short piece of tubing from the pump-head tubing to a measuring bucket.
- 2. Turn on the pump and establish a suitable pumping rate. For the multi-volume purge method, the rate will generally be a relatively fast rate that the well will sustain without elevating turbidity. For the low-flow method the pump rate is established at a slower rate to maintain a minimal and stable drawdown level.
- 3. Proceed with the measurement of water quality parameters and adjust the pump rate as needed to achieve low turbidity and stable drawdown.
- 4. When the well purge has been determined to be sufficient, fill containers for metals and classical analyses directly from the pump outlet. There is no need to interrupt pumping. The tubing should be held at the opening of the container and should not touch the container during filling. Protect caps from dust and debris during filling.
- 5. After filling the containers for metals and classical analyses stop the pump. Make sure that the tubing leading into the well is secured against movement during the following operations.
- 6. Create a crimp in the well tubing approximately one foot from the pump and grasp the crimped tubing in one hand. It is generally most effective to create a double 'Z' crimp.
- 7. Cut the sample tubing between the crimp and the pump. The tightly-held crimped tubing should keep water from running back into the well. In lieu of

Effective Date: April 26, 2017

- cutting the tubing, the well tubing can be disconnected from the pump and a short piece of tubing connected in its place.
- 8. Insert both free ends of the tubing into the ferrule-nut fittings of a pre-cleaned Teflon® transfer cap assembly and tighten the nuts. Attach the transfer cap assembly to the first glass container for semi-volatile analysis and securely tighten the threaded ring.
- 9. Turn the pump on. Very slowly release the 'Z' crimp in the sample tubing. As vacuum builds up in the sample container, water should begin to move up the sample tubing instead of back into the well. If after several minutes water has not begun moving up the tubing, check the tightness of fittings and the attachment of the cap to the bottle. Allowing water to rush back down the tubing from the 'Z' crimp can surge the well and elevate turbidity.
- 10. Fill the container to about halfway between the shoulder and the neck. Crimp the well tubing. Move the transfer cap to any additional bottles and repeat the filling process.
- 11. When finished filling bottles with the transfer cap, again crimp the tubing. Remove the well tubing from the transfer cap and reattach it to the pump. Slowly run the pump and release the crimp until water is approaching the flexible peristaltic tubing.
- 12. Make a kink or otherwise mark the tubing at the top of the casing in case the tubing needs to be reinserted for additional sample volume. Slowly remove the tubing from the well and coil it in one hand in loose coils. With the top end of the tubing blocked, water is retained in the tubing as it is withdrawn, much as in a capped soda straw, hence the name for this method.
- 13. Remove the top from a 40 ml VOC vial and position the end of the sample tubing near the top of the vial. Reverse the pump direction and turn the speed knob to its slowest position. Turn on the pump and slowly increase speed until water slowly fills the vial. Fill the vial with a slow laminar flow that does not agitate the water in the vial or entrain bubbles. Continue to fill the vial until a convex meniscus forms on the top of the vial and turn off the pump.
- 14. Carefully screw the septum-lid to the vial and fasten firmly. Invert the vial and tap on your knuckles to check for bubbles. Carefully add additional volume to the vial if necessary. Small bubbles are undesirable but may be unavoidable with some media, especially when using pre-preserved vials.
- 15. Repeat the filling process for additional vials. Avoid partially filling vials as the available water in the tubing is used. If more volume is required than that contained in the tubing, purge the remaining water from the tubing and reinsert

the tubing in the well to the level marked previously. Run the pump to refill the tubing. If performing Low-Flow sampling, run additional volume through the pump to purge any water that may have been collected from the stagnant water column.

16. Fill additional vials as needed. Be sure that any water that has contacted the flexible peristaltic tubing is not pumped into a vial.

3.7.2 Use of Submersible Centrifugal Pumps

Submersible centrifugal pumps are used in wells of 2" diameter and larger. They are especially useful where large volumes of water are to be removed or when the groundwater surface is a large distance below ground surface. Commonly used pumps are the Grundfos® Redi-Flo2, the Geotech GeoSub, and the various 'Monsoon' style pumps. Other pumps are acceptable if constructed of suitable materials.

When used with the Multiple-Volume Purge method, the pump is generally used only to purge, with sampling performed with a bailer. In this use, the pump can be used with polyethylene or other tubing or hose that will not contribute contaminants to the well. The pump and tubing is decontaminated between wells per the relevant provisions of SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205). When used in this application the pump should be equipped with a check valve to prevent water in the discharge tubing or hose from running back down into the well.

When used for Low-Flow purging and sampling the pump must be constructed of stainless steel and Teflon®. Pump cleaning at each well follows the more stringent procedures described in SESD Operating Procedure for Field Equipment Cleaning and Decontamination SESDPROC-205) for this application. The sample tubing should be either new Teflon® tubing, or tubing dedicated to each well. Dedicated tubing would ideally be cleaned between uses, but tubing stored in the well casing between uses is acceptable, although caution should be exercised where very high concentrations of contaminants have been sampled in a well.

3.7.3 Use of Bailers

Bailers are a common means of sampling when the Multiple-Volume Purge method is used. They are occasionally used for purging when other equipment is not available or has failed. As bailers surge the well on each withdrawal, it is very difficult to lower turbidity adequately during a well purge, and when used for sampling they can elevate turbidity in a well before all sample volume is collected. If not lowered carefully into the top of the water column, the agitation may strip volatile compounds. Due to the difficulties and limitations inherent in their use, other sampling or purging means should generally be given preference.

Bailers should be closed-top Teflon® bailers with Teflon® coated stainless steel leaders used with new nylon haul rope. They are lowered gently into the top of the water column, allowed to fill, and removed slowly. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging and during sampling, to minimize turbidity and loss of volatile organic constituents.

If the well has previously been purged with a pump, there is likely stagnant water at the top of the well that was above the pump or tubing inlet. Several bailers of water should be retrieved and discarded to assure the upper stagnant water has been removed.

When sampling, containers are filled directly by pouring from the outlet at the top of the bailer. Containers for metals analysis should be filled first in case the bailing process increases well turbidity. VOC vials should be filled carefully and slowly with a laminar flow to reduce agitation and the stripping of VOCs.

3.7.4 Use of Bladder Pumps

Bladder pumps use a source of compressed gas to compress and release a bladder straddled by check valves within the pump body. As the bladder is compressed, water is expelled out the upper check valve to the surface. When gas pressure is released, the bladder refills as well water enters the lower pump inlet. A control unit is used to control the pressure and timing of the bladder inflation gas flow.

Bladder pumps are capable of pumping from moderate depths to water, but are not capable of high flow rates. As they operate cyclically, the well is surged slightly on each cycle and it may be difficult to lower turbidity in sensitive or poorly developed wells. As the entire sample train is under positive pressure and the pumps develop little heat, they are ideal for sampling VOCs.

Prior to sampling and between each well the pumps are cleaned internally and externally per the provisions of SESD Operating Procedure for Field Decontamination (SESDPROC-205) and a new Teflon® bladder installed. New (or dedicated) Teflon® sample tubing is used at each well, although polyethylene tubing can be used for the compressed gas drive line and cleaned between each well.

3.7.5 Use of Inertial Pumps

Inertial pumps consist of a check valve which is affixed to the lower end of semi-rigid tubing. The tubing and valve are cycled up and down, allowing water to alternately be drawn into the check valve inlet and then pulled up towards the surface. Two commonly used inertial pumps are the Waterrra® pump for wells larger than 1" and the Geoprobe® Tubing Check Valve for small diameter wells. The primary use of these pumps is in well development where their near-immunity to silt is an advantage. Inertial pumps should not be used for the final well purge or for sampling as there is a low likelihood of

reducing turbidity to appropriate levels and they have the potential to strip volatiles from the water column through agitation.

To set up the pump, the check valve is screwed onto the discharge tubing where it will cut its own threads. In the case of the Waterra® pump, a surge block can also be pressed onto the check valve. The pump is lowered into the well to the screened interval and rapidly cycled up and down a distance of 3"-12". The stroke length and speed are adjusted for pumping effect. Electric actuators can be used to reduce the effort involved. The pump should be moved to different levels in the screen to surge the entire screen. The pump can occasionally be lowered to the bottom of the well to vacuum out silt. Any silt that clogs the valve is usually quickly rinsed out by the pump cycling and if the clog remains the pump is easily retrieved and redeployed.

The surging activity is usually continued until turbidity is lowered to a measurable range and cannot easily be lowered further. Further development or purging is then conducted with other pumps.

3.8 Wells With In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, and in other applications. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps.

A permanent monitoring well with an in-place pump may be treated as other monitoring wells without pumps. Since the in-place pump is generally "hard" mounted at a preselected depth, it cannot be moved up or down during purging and sampling. If the pump inlet is above the screened interval, the well should be sampled using the Multiple-Volume Purge method. If the pump intake is located within the screened interval, the well can be sampled using Low-Flow procedures. Known details of pump type and construction, tubing types, pump setting depths, and any other available information about the system should be recorded in the field logbook.

In the case of the other types of wells, e.g., municipal, industrial and residential supply wells, there is typically not enough known about the construction aspects of the wells to apply the same criteria as used for monitoring wells. The volume to be purged in these situations therefore depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing under the conditions described.

3.8.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot,

valve or other sampling point should be found located between the pump and the storage tank. If no valve is present, locate and use the valve closest to the tank. Measurements of field parameters are recorded immediately prior to the time of sampling.

3.8.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Often under these conditions, 15 to 30 minutes of purging will be adequate. Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purge and the final measurements made at the time of sampling should be considered the measurements of record for the event.

3.9 Temporary Monitoring Wells

3.9.1 General Considerations

As temporary wells are installed for immediate sample acquisition, the procedures used to purge temporary ground water monitoring wells may differ from those for permanent wells. Temporary wells include standard well screen and riser placed in boreholes created by hand augering or drilling, or they may consist of a drive rod and screen such as a direct-push Geoprobe® Screen Point that is driven into place at the desired sampling interval. As aquifer water enters the sampler immediately upon deployment, the requirement to remove several volumes of water to replace stagnant water does not necessarily apply. In practice, developing and purging the well to usable turbidity levels will remove many times the water that would be removed in a Multiple-Volume Purge with calculated well volumes. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply standard permanent monitoring well purging criteria to achieve representative aquifer conditions in the sample.

3.9.2 Development of Temporary Wells

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, causing extreme turbidity. The goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure.

The following procedure has been found to be effective in developing and sampling small diameter temporary wells where a peristaltic pump can be used. Turbidity can generally be lowered to 50 NTU at the time of sampling and turbidity less than 10 NTU is often achieved.

- 1. Cut peristaltic tubing to reach to the bottom of the well. Connect to a peristaltic pump and begin pumping at a high rate.
- 2. Use the tubing to vacuum out sediment at the bottom of the well.
- 3. Aggressively surge the end of the tubing in the screened interval by cycling the tubing rapidly up and down. Periodically repeat vacuuming of the well bottom.
- 4. When a visible 'break' to a lower turbidity is observed, cease surging the well and begin lowering the pumping rate.
- 5. When the water clears (turbidity < 100-200 NTU) begin raising the end of the tubing to the top of the water column.
- 6. Continue purging from the top of the water column, lowering the pump speed as required to lower turbidity. When adequately low turbidity and stable water quality parameters have been achieved, sampling can proceed.

Where the water level is below the limit of suction in a small diameter temporary well, a Geoprobe® mechanical bladder pump can be used for purging and sampling. The well should first be developed with an inertial pump to remove the bulk of silt and suspended particles that could clog the check valves of the bladder pump. The inertial pump is used to vacuum out the bottom of the well and surged in the screened interval until a 'break' to lower turbidity is observed prior to deployment of the bladder pump. Since the mechanical bladder pump requires cumbersome redeployment to change its pumping level, it should be deployed low enough in the water column that the water level will not be lowered below the pump during purging and sampling. The mechanical bladder pump is generally deployed above the screened interval to facilitate the settling of particles, but below the top of the water column to alleviate the need to reset the pump. Detailed instructions on the deployment of the pump can be found in SESDPROC203, Pump Operation.

3.9.3 Decommissioning of Temporary Wells

After temporary wells have fulfilled their purpose, they should be properly decommissioned similar to permanent wells. In general, the casings and screens can be easily removed and the borehole should then be pressure grouted from the bottom of the original borehole to prevent surface contamination of the aquifer, cross-connection of aquifers, and to remove a potential vapor pathway.

Direct-push screen-point wells may be decommissioned by one of two methods.

1. A disposable screen is used. The sampling sheath is pulled off of the screen and a 30% solids bentonite grout is pumped down the tool string as the rods are withdrawn.

Grout volumes are measured during pumping to assure that the hole is completely filled. The disposable screen is left behind at the bottom of the borehole.

2. The screen is removed with the sampler sheath and tool string. The hole is immediately re-entered with an empty sample sheath with disposable point. Upon reaching the original total depth of the temporary well, 30% solids bentonite grout is pumped down the tool string with the pumped volume monitored during tool string withdrawal to assure that the hole is completely filled.

A system is available to insert a small diameter grouting tube down through the screen-point screen. Grout is pumped through the grouting tube while the tools are withdrawn. SESD does not use this system as grout denser than 20% solids cannot reliably be installed with this system.

Additional guidance on decommissioning may be found in SESDGUID-101, Design and Installation of Monitoring Wells.

3.9.4 Other Considerations for Direct-Push Groundwater Sampling

With certain direct push sampling techniques, such as the HydropunchTM and other discrete samplers used with cone-penetrometer rigs, purging is either not practical or not possible. The sampling device is simply pushed or driven to the desired depth and opened, whereupon the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the sampler may collect a turbid sample inappropriate for metals analyses or the sample may have inadequate volume to achieve desired reporting levels.

3.10 Wells Purged to Dryness

In some situations, even with slow purge rates, a well may be purged dry in the Multiple-Volume Purge method or stable drawdown cannot be maintained in the Low-Flow method. In these cases, the well should be purged to dryness (evacuated) and sampled upon recovery of adequate volume for sampling. Sampling should occur as soon as adequate volume has recovered. The field parameters should be measured and recorded at the time of sample collection as the measurements of record for the sampling event.

Sampling under these conditions is not ideal and suitable qualifications of the data should be included in the report. Water cascading down the screen into the well may strip volatile compounds and elevate turbidity. Although suffering from other limitations, No-Purge methods may prove useful for these wells.

4 Additional Purging and Sampling Considerations

4.1 Field Care of Purging Equipment

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible centrifugal or bladder pumps to purge wells which are excessively contaminated with oily compounds as it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative equipment, such as bailers or peristaltic pumps, should be considered.

4.2 Investigation Derived Waste

Purging and field cleaning of equipment generates liquid investigation derived waste (IDW), the disposition of which must be considered. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for guidance on management or disposal of this waste.

4.3 Sample Preservation

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult the Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM) for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

4.4 Special Sample Collection Procedures

4.4.1 Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which contacts the water in the well must be cleaned in accordance with the cleaning procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-

SESD Operating Procedure

Page 31 of 34

SESDPROC-301-R4

Groundwater Sampling

Groundwater Sampling(301)_AF.R4

206). Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Rinse blank samples should be collected to verify the adequacy of cleaning when using a sampling pump other than a peristaltic pump.

4.4.2 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, sufficiently low turbidity is difficult to achieve and maintain. Removal and insertion of equipment after the purge or during sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to fill sample containers for metals analysis first. The preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds, and finally volatile organic compounds.

4.5 Filtering

As many contaminants are known to sorb to soil particles, the normal goal of sampling is to reduce the presence of these particles (measured by turbidity) in order that the dissolved concentration of contaminants can be obtained. However, transport of sorbed contamination on colloidal particles can be a means of contaminant transport on some sites. For this reason, the SESD approach is to reduce turbidity through the careful purging of wells, rather than through filtering of samples, in order that the colloidal particles would be included in the sample.

As a standard practice, ground water samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter and used for flow system analysis and for the purpose of geochemical speciation modeling. Filtration is not acceptable to correct for improperly designed or constructed monitoring wells, inadequate well development, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the ground water sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis:

- 1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the SESD Guidance Document, Design and Installation of Monitoring Wells (SESDGUID-001).
- 2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with USEPA approved methods.

3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the redevelopment or re-installation of permanent ground water monitoring wells or the implementation of carefully conducted low flow rate sampling techniques.

If filtration is necessary for purposes of geochemical modeling or other **pre-approved** cases, the following procedures are suggested:

- 1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.
- 2. When using pumps for sampling, the filter can generally be attached directly to the pump outlet. When sampling with a bailer or when otherwise required, an initial unfiltered sample with extra volume will be collected, and a peristaltic pump with filter used to decant and filter the sample to the final sample container.
- 3. Use a 0.45 µm pore-size filter to remove most non-dissolved particles. A 5 µm or 10 µm pore-size filter should be used for the purpose of determining colloidal constituent concentrations.
- 4. Fill the filter and rinse with approximately one additional filter volume prior to filling sample bottles

Potential differences can result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from the following: 1) Metals in Ground Water: Sampling Artifacts and Reproducibility; 2) Filtration of Ground Water Samples for Metals Analysis; and 3) Ground Water Sampling - A Workshop Summary. See Section 1.4, References, for complete citation for these documents.

4.6 Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in the following: 1) Sampling for Organic Chemicals and Microorganisms in

the Subsurface; 2) <u>Handbook for Evaluating Water Bacteriological Laboratories</u>; and 3) <u>Microbiological Methods for Monitoring the Environment, Water and Wastes</u>. See Section 1.4, References, for complete citation for these documents.

4.7 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206). Malfunctioning equipment should be labeled in the field and repaired, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

4.8 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water levels measured according to the SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations, pumping rates during purging, and, driller or boring logs. This information should be documented in the field records.

4.9 Well Development

Wells may be encountered that are difficult to sample effectively due to inadequate initial development or the need for redevelopment due to scaling, sedimentation, corrosion, or biofouling. These wells may produce water only at low flow rates or water with chronically elevated turbidity. Redevelopment of these wells should be considered as the process can improve sample quality and speed field operations. Well development procedures are described in Design and Installation of Monitoring Wells (SESDGUID-101).

Region 4

U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE				
Title: Field Specific Conductance Measurement				
Effective Date: July 13, 2016	Number: SESDPROC-101-R6			
Aut	thors			
Name: Timothy Simpson Title: Environmental Scientist Signature: July Date: 07/07/2016				
Approvals				
Name: John Deatrick Title: Chief, Ecological Assessment Branch Signature: Date: 7/1/16				
Name: Hunter Johnson				
Title: Field Quality Manager, Science and Ecosystem Support Division				
Signature: /2/1/16				

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-101-R6, Field Specific Conductance	July 13, 2016
Measurement, replaces SESDPROC-101-R5	
General: Corrected any typographical, grammatical, and/or editorial errors. Throughout the document mention of quality system or SESD quality system was replaced with Field Branches Quality System or FBQS.	
Cover Page: Omitted Hunter Johnson as an author. Updated cover page	
to represent SESD reorganization. John Deatrick was not listed as the	
Chief of the Field Services Branch.	
SESDPROC-101-R5, Field Specific Conductance	August 30, 2012
Measurement, replaces SESDPROC-101-R4	<i>U</i> ,
SESDPROC-101-R4, Field Specific Conductance	January 13, 2012
Measurement, replaces SESDPROC-101-R3	
SESDPROC-101-R3, Field Specific Conductance	August 12, 2011
Measurement, replaces SESDPROC-101-R2	
SESDPROC-101-R2, Field Specific Conductance	June 13, 2008
Measurement, replaces SESDPROC-101-R1	
SESDPROC-101-R1, Field Specific Conductance	November 1, 2007
Measurement, replaces SESDPROC-101-R0	
SESDPROC-101-R0, Field Specific Conductance Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1	Gener	al Information	4
		urpose	
		cope/Application	
		ocumentation/Verification	
		eferences	
		eneral Precautions	
	1.5.1		
	1.5.2	Procedural Precautions	
2	Qualit	y Control	6
3	Field S	Specific Conductance Measurement Procedures	7
		eneral	
	3.2 Ir	strument Calibration and Verification	7
		ample Measurement Procedures	
,		perational Checks	

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field specific conductance measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators when measuring the specific conductance of aqueous phase environmental media in the field. On the occasion that SESD field investigators determine that any of the procedures described in this section cannot be used to obtain specific conductance measurements of the media being sampled, and that another method must be used to obtain said measurements, the variant instrument and/or measurement procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 *Safety*

Proper safety precautions must be observed when conducting field specific conductance measurements. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field specific conductance measurements pertinent to the sampling event, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be recorded in the field logbook for the event. All records should be entered according to the procedures outlined in the SESD Operating Procedure Logbooks (SESDPROC-010, most recent version).

Care should be taken to not contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to the manufacturer's specifications.

2 **Quality Control**

All specific conductance meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108, most recent version). Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to ensure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized* in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.

If at any time during a field investigation it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Specific Conductance Measurement Procedures

3.1 General

Specific conductance is a measure of the ability of an aqueous solution to conduct an electric current and is customarily reported in microsiemens per centimeter (μ S/cm) or micromhos per centimeter (μ mhos/cm) at 25°C. It is important to note that if the specific conductance measurements are for NPDES reporting purposes, the meter and conductivity cell should be verified by comparing against a laboratory meter with a platinum-electrode type conductivity cell.

3.2 Instrument Calibration and Verification

Many brands of instruments are commercially available for the measurement of specific conductance incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate.

Conductivity is affected by temperature; therefore, for instruments that do not automatically compensate for temperature, the user should document temperature first so that appropriate adjustments can be made in accordance with the manufacturer's instructions and/or method. The following are basic guidelines for calibration/verification and are provided as an example:

- 1. Verify the meter's internal temperature sensor (thermistor) against a National Institute of Standards and Technology (NIST) traceable thermometer and note any differences between the thermistor and the NIST-traceable thermometer in the logbook. If the temperatures do not agree within ± 4°C, the unit must be repaired or replaced. Alternatively, if the meter can be used in a manual temperature compensation mode, the NIST-traceable thermometer may be used for temperature readings and the necessary corrections applied. Check and record the temperatures of the standards and the samples.
- 2. Rinse the probe with de-ionized water and blot dry before conducting the following calibration and verification checks.
- 3. Immerse the probe in the first standard solution and calibrate or verify the meter against that solution. Fresh standards should be used for each calibration. After the initial standard, calibrate and/or verify the meter using additional standards, as appropriate. Rinse the probe with de-ionized water and blot dry or otherwise remove excess rinse water between the different standards. Record the standard values/temperatures used to calibrate or verify the meter.

Note: Some instruments require that calibration standards reflect the anticipated specific conductance of the media being measured.

- 4. Some meters will auto-recognize standards during calibration. For example, the Orion Star Series meter will auto-recognize standards 1413 μ S/cm, 100 μ S/cm and 12.9 mS/cm. If the meter is calibrated in a manner where it does not auto-recognize the standard, and the meter is not accurate to within \pm 10 % of the standard solution(s) known values, the meter or probe should be repaired or replaced. If this condition can be corrected by adjusting the cell constant of the probe, refer to the instruction manual and make the adjustment.
- 5. After calibration is complete, place the probe back into the calibration standard used and record a post-calibration reading. Record a post calibration reading for each standard used. If the meter is not accurate to within \pm 10 % of the standard solution(s) known values, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the probe and/or meter should be replaced.
- 6. Once the meter has been properly calibrated and verified (steps 1-5 above), it is ready for use. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution. Certain meters may require that the instrument be left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against the known calibration standards if used for extended periods (> 4 hrs).

3.3 Sample Measurement Procedures

The following procedures should be followed when conducting field specific conductance measurements of grab samples:

- 1. Collect the sample, check and record its temperature.
- 2. Correct the instrument's temperature adjustment to the temperature of the sample (if required).
- 3. Immerse the probe in the sample keeping it away from the sides and bottom of the container. It is important that the center portion of the probe be wetted by the sample.
- 4. Allow meter to stabilize. Record the results in a logbook.

5. Rinse probe with de-ionized water.

The following procedures should be followed when conducting in-situ field specific conductivity measurements:

- 1. Place the probe into the media to be measured and allow the specific conductivity and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.
- 2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 Operational Checks

Even though it is not necessary to re-calibrate conductivity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an extreme temperature change, have impacted the meter's performance. If an operational check is warranted, the following procedures should be followed to ensure that the performance of the meter has changed.

Check the conductivity meter with fresh conductivity standard. Rinse the conductivity probe with deionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate conductivity standard. If the measured conductivity value is not with \pm 10% of the standard, the probe should be re-calibrated. If the probe is still not within \pm 10% of the standard, the probe should be repaired or replaced. These measurements must be recorded in the field logbook.

A post-operation instrument verification check should be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.



TETRA TECH

Subject

STANDARD OPERATING PROCEDURE

Page
1 of 7
Revision
5

Applicability

Tetra Tech, Inc., NUS Operating Unit

Prepared

Earth Sciences Department

(GUIDANCE)

SAMPLE NOMENCLATURE

Approved johnston
T. Johnston @tetratec
h.com

Digitally signed by: tom. johnston@tetratech.com DN: CN = tom. johnston@tetratech.com Date: 2016 11 17 11 06:04 -

TABLE OF CONTENTS

SECT	ΓΙΟΝ		PAGE
1.0	PURPO	SE	2
2.0	SCOPE	AND APPLICABILITY	2
3.0	GLOSS	ARY	2
4.0	RESPO	NSIBILITIES AND PERSONNEL QUALIFICATIONS	2
5.0	PROCE	DURES	3
	5.1 5.2 5.3 5.4 5.5 5.6	INTRODUCTIONSAMPLE IDENTIFICATION FIELD REQUIREMENTS	
6.0	DEVIAT	TIONS	7

Subject	Number	Page
	CT-04	2 of 7
SAMPLE NOMENCLATURE	Revision	Effective Date
	5	11/20/2016

1.0 PURPOSE

This document specifies a consistent sample nomenclature system that facilitates subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix
- Sorting of data by depth
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints (maximum of 20 characters)

2.0 SCOPE AND APPLICABILITY

The methods described in this document are designed to be used consistently for all projects requiring electronic data. Other contract- or project-specific sample nomenclature requirements may also be applicable. If project-specific requirements dictate the use of a different system of nomenclature than what is described in this guidance, the objectives identified above must be borne in mind when developing the alternate nomenclature. Consultation with the NUS Operating Unit database group is advisable in those cases. The database group will help ensure that sample nomenclature is compatible with the affected databases.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Program Manager</u> - The Program Managers (or their designees) are responsible for informing contract-specific Project Managers (PMs) of the existence and requirements of this document. Program Manager qualifications are described in the current NUS Operating Unit Quality Assurance Program Manual available on the intranet Quality Assurance link.

Project Manager - Project Managers (PMs) determine the applicability of this document based on: (1) program-specific requirements and (2) project size and objectives. PMs (or their designees) ensure that sample nomenclature requirements are thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and are consistent with this document, if relevant. PMs ensure that the Field Operations Leader (FOL) is familiar with the sample nomenclature system. Program Managers appoint PMs based on their experience and past performance and qualifications as described in the current NUS Operating Unit Quality Assurance Program Manual, which is available on the intranet Quality Assurance link.

<u>Field Operations Leader</u> - The FOL ensures that all field technicians or sampling personnel are thoroughly familiar with this document and the project-specific sample nomenclature system and that they implement the nomenclature system in accordance with this document.

General personnel qualifications for sample nomenclature activities in the field include the following:

Subject	Number CT-04	Page 3 of 7
SAMPLE NOMENCLATURE	Revision 5	Effective Date 11/20/2016

- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for field documentation, sample handling, packaging, and shipping.

5.0 PROCEDURES

5.1 INTRODUCTION

The sample identification (ID) system may consist of as few as eight but not more than 20 distinct alphanumeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the laboratory has three segments and shall be as follows, where "A" indicates "alpha," and "N" indicates "numeric":

A or N	AAA	A or N
3 or 4 Characters	2 or 3 Characters	3 to 6 Characters
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and sediment sample ID

A or N	AAA	A or N	NNNN
3 or 4 Characters	2 or 3 Characters	3 to 6 Characters	4 Characters
Site identifier	Sample type	Sample location	

(2) Aqueous (groundwater or surface water) sample ID

A or		AAA	A or N	NN	A
3 or 4 Cha		2 or 3 Characters	3 to 6 Characters	2 Characters	1 Character
Site ider	ntifier	Sample type	Sample location	Round number	Filtered sample only

Note 1: Sampling dates may be used in place of round numbers.

Note 2: The "-F" may be omitted from the sample ID if there is another way to definitively indicate on chain of custody forms and in the NUS Operating Unit database which portion of a samples is designated for total species analysis (unfiltered samples) and which is designated for dissolved species analysis (filtered samples).

(3) Biota sample ID

A or N	AAA	A or N	AA	NNN
3 or 4 Characters	2 or 3 Characters	3 to 6 Characters	2 Characters	3 Characters
Site identifier	Sample type	Sample location	Species identifier	Sample group number

Subject	Number CT-04	Page 4 of 7
SAMPLE NOMENCLATURE	Revision 5	Effective Date 11/20/2016

5.2 SAMPLE IDENTIFICATION FIELD REQUIREMENTS

The various fields in the sample ID include but are not limited to the following:

- Site identifier
- Sample type
- Sample location
- Sample depth
- Sampling round number
- Filtered
- Species identifier
- Sample group number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary because many facilities/sites have multiple individual sites, Solid Waste Management Units (SWMUs), Operable Units (OUs), etc. Several examples are presented in Section 5.3.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3.

The sample location must be at least a three-character field but may have up to six characters (alpha, numeric, or a mixture). The six characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) in units of feet at which a soil sample is collected; and the depth in units of inches bgs at which a sediment sample was collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to three characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet or boring log, in the logbook, etc.

A two-digit round number will be used to track the number of aqueous samples collected from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

Note: If samples are filtered in the field, the results will be segregated in the NUS Operating Unit database according to whether they represent the unfiltered sample or filtered sample. The chain of custody form must be marked to indicate which portion of a sample is filtered. This may be accomplished by appending "-F" to the end of the sample number or by otherwise indicating on the chain of custody form which sample portion is filtered (for dissolved species analysis) as opposed to unfiltered (for total species analysis).

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3.

The three-digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individuals caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a

Subject	Number	Page
	CT-04	5 of 7
SAMPLE NOMENCLATURE	Revision	Effective Date
	5	11/20/2016

given location will be assigned the sample group number 001, and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 **EXAMPLE SAMPLE FIELD DESIGNATIONS**

Examples of each of the fields are as follows:

Site identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern (AOC) 1

125 - SWMU 125

000 - Base- or facility-wide sample (e.g., upgradient well)

BBG - Base background

The examples cited are only suggestions. Each PM (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample type - Examples of sample types are as follows:

AH - Ash Sample

AS - Air Sample

BM - Building Material Sample

BSB - Biota Sample Full Body

BSF - Biota Sample Fillet

CP - Composite Sample

CS - Chip Sample

DS - Drum Sample

DU - Dust Sample

FP - Free Product

IDW - Investigation-Derived Waste Sample

LT - Leachate Sample

MW - Monitoring Well Groundwater Sample

OF - Outfall Sample

RW - Residential Well Sample

SB - Soil Boring Sample

SD - Sediment Sample

SC - Scrape Sample

SG - Soil Gas Sample

SL - Sludge Sample

SP - Seep Sample

SS - Surface Soil Sample

ST - Storm Sewer Water Sample

SW - Surface Water Sample

TP - Test Pit Sample

TW - Temporary Well Sample

WC - Well Construction Material Sample

WP - Wipe Sample

WS - Waste/Solid Sample

WW - Wastewater Sample

Sample location - Examples of the location field are as follows:

Subject	Number CT-04	Page 6 of 7
SAMPLE NOMENCLATURE	Revision 5	Effective Date 11/20/2016

001 - Monitoring Well 1

N32E92 - Grid location 32 North and 92 East

D096 - Investigation-derived waste drum number 96

Species identifier - Examples of species identifier are as follows:

BC - Blue Crab
GB - Blue Gill
CO - Corn
SB - Soybean

5.4 **EXAMPLES OF SAMPLE NOMENCLATURE**

A first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F (or without the "-F" if otherwise indicated as to which portion of sample is filtered and which is unfiltered)..

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140006. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full-body analysis, the first time a minnow trap was checked at grid location A25 of SWMU 1415, three small blue gills were captured, collected, and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415), the sample ID would be 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash (-F).

Note: It may be more useful for project staff to use feet bgs instead of inches bgs to indicate sediment sampling depths. Whichever units of measure are used for sampling of any matrix, the units must be clearly documented to ensure there is no confusion. Consistency with previous sample nomenclature also will reduce any chance of confusion.

5.5 FIELD QA/QC SAMPLE NOMENCLATURE

Field Quality Assurance (QA)/Quality Control (QC) samples are designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

Subject	Number CT-04	Page 7 of 7
SAMPLE NOMENCLATURE	Revision 5	Effective Date 11/20/2016

AA	NNNNN	NN	-F
QC type	Date	Sequence number (per day)	Filtered (aqueous only, if needed)

Note: The "-F" may be omitted from the sample ID if there is another way to definitively indicate on chain of custody forms which portion of a samples is designated for total species analysis (unfiltered samples) and which is designated for dissolved species analysis (filtered samples).

The QC types are identified as:

TB = Trip Blank

RB = Rinsate Blank (Equipment Blank)

FD = Field Duplicate

AB = Ambient Conditions Blank

WB = Source Water Blank

The sampling time recorded on the chain-of-custody form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log Sheet (see SOP SA-6.3, Field Documentation).

5.6 EXAMPLES OF FIELD QA/QC SAMPLE NOMENCLATURE

The first duplicate of the day for a filtered groundwater sample collected on June 3, 2016, would be designated as FD06031601-F (or without the "-F" if otherwise indicated on the chain of custody form as to which portion of sample is filtered and which is unfiltered).

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2016, would be designated as FD11171603.

The first trip blank associated with samples collected on October 12, 2016, would be designated as TB10121601.

The only rinsate blank collected on November 17, 2016, would be designated as RB11171601.

6.0 DEVIATIONS

Deviations from instructions specified in this document are allowed but sufficiently accurate and precise descriptions of sample nomenclature must be described in the site-specific planning documents to prevent confusion over sample identification.



STANDARD OPERATING PROCEDURE

Number GH-1.2	Page 1 of 9
Effective Date 02/17/2016	Revision 4

Applicability

Tetra Tech, Inc., NUS Operating Unit

Prepared

Earth Sciences Department

Subject EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT

Approved johnston
T. Johnston @tetratec h.com

Digitally signed by, tom. johnston@tetratech.com DN: CN = tom. johnston@tetratech.com Date: 2017.02.20 14:16:25 -05'00'

TABLE OF CONTENTS

SECT	<u>ION</u>	<u>PAGE</u>
1.0	PURP	OSE2
2.0	SCOP	E2
3.0	GLOS	SARY2
4.0	RESP	ONSIBILITIES2
5.0	PROC	EDURES
	5.1 5.2 5.3 5.3.1 5.3.2 5.3.3 5.3.4 5.3.5 5.3.6 5.4 5.5	Preliminary Evaluation 3 Field Inspection 3 Water Level (Hydraulic Head) Measurements 4 General 4 Water Level Measuring Techniques 5 Methods 5 Water Level Measuring Devices 6 Data Recording 6 Specific Quality Control Procedures for Water Level Measuring Devices 7 Equipment Decontamination 7 Health and Safety Considerations 7
6.0	RECO	RDS
ATTA	CHMEN	
	A B	MONITOIRNG WELL INSPECTON SHEET (EXAMPLE)

Subject	Number	Page
EVALUATION OF EXISTING	GH-1.2	2 of 9
MONITORING WELLS AND WATER	Revision	Effective Date
LEVEL MEASUREMENT	4	02/17/2017

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

<u>Water Table</u> - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

<u>Site Geologist/Hydrogeologist</u> - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

<u>Field Personnel</u> - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

Subject	Number	Page
EVALUATION OF EXISTING	GH-1.2	3 of 9
MONITORING WELLS AND WATER	Revision	Effective Date
LEVEL MEASUREMENT	4	02/17/2017

5.1 **Preliminary Evaluation**

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal, or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 <u>Field Inspection</u>

During the onsite inspection of existing monitoring wells, note the following features and others as appropriate:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

Subject	Number	Page
EVALUATION OF EXISTING	GH-1.2	4 of 9
MONITORING WELLS AND WATER	Revision	Effective Date
LEVEL MEASUREMENT	4	02/17/2017

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted (at a minimum):

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and potential well obstructions. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 <u>Water Level (Hydraulic Head) Measurements</u>

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

Measure all groundwater levels to the nearest 0.01 foot, and record the levels in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading.

If not already known, measure the total depth of the well and record this depth. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, ensure that there is a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful,

Subject	Number	Page
EVALUATION OF EXISTING	GH-1.2	5 of 9
MONITORING WELLS AND WATER	Revision	Effective Date
LEVEL MEASUREMENT	4	02/17/2017

the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level measurements should be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be measured in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such measurements should be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map should be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels may be measured by several different techniques, but the same steps should be followed in each case. The proper sequence is as follows:

- 1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.
- 2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):
 - Well number.
 - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
 - Time and day of the measurement.
 - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

Subject	Number	Page
EVALUATION OF EXISTING	GH-1.2	6 of 9
MONITORING WELLS AND WATER	Revision	Effective Date
LEVEL MEASUREMENT	4	02/17/2017

5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, lower the probe slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Record water level measurements, time, data, and weather conditions in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements should be measured from a known reference point (see Section 5.3.1). The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point should be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within a well.

Subject	Number	Page
EVALUATION OF EXISTING	GH-1.2	7 of 9
MONITORING WELLS AND WATER	Revision	Effective Date
LEVEL MEASUREMENT	4	02/17/2017

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device should be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices should be calibrated to 0.01 foot accuracy and any adjustments/corrections should be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the <u>corrected</u> readings should be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

Perform and initial monitoring of the well headspace and breathing zone concentrations using a PID or FID to determine required levels of protection.

6.0 RECORDS

Record all field procedures, tests and observations in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

Subject Number Page **EVALUATION OF EXISTING** GH-1.2 8 of 9 MONITORING WELLS AND WATER Revision Effective Date LEVEL MEASUREMENT 4 02/17/2017 ATTACHMENT A MONITORING WELL INSPECTION SHEET (EXAMPLE) **Monitoring Well Inspection Sheet** Project Name: ____ Date: ____ Location: ____ Time: _____ Tidally Influenced: Y / N Personnel: _____ Field Measurements PID Reading PPM Well ID Depth to Water * Total Depth * Flush Mt./ Stick-up Well Construction Details (Taken from construction logs) Total Depth * Ground Elev. Top/Btm Screen Check List: Riser Pipe Material: Riser Notched for Surveyors: Well ID Tag In-place: Well security: Photo taken: **Condition of Well:** Protective Case: Riser: Well Pad: Other: Presence/Evidence of: Standing Water Around Well: Existing Sampling Equipment: Sediment build-up in Well Btm: Comments:

019611/P Tetra Tech

 $^{^\}star$ = Measurements are from the top of the inner case to the nearest 0.01'

Subject	Number	Page
EVALUATION OF EXISTING	GH-1.2	9 of 9
MONITORING WELLS AND WATER LEVEL MEASUREMENT	Revision 4	Effective Date 02/17/2017

ATTACHMENT B GROUNDWATER LEVEL MEASUREMENT SHEET (EXAMPLE)

Project Name Location: Weather Con				Project No.: Personnel:		- 20
ridally Influ		Yes No		Measuring Device: Remarks:		
Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Comments

019611/P Tetra Tech



STANDARD OPERATING PROCEDURE

Number	Page
SA-1.1	1 of 36
Effective Date	Revision
7/15/2016	9

Applicability

Tetra Tech, Inc., NUS Operating Unit

Prepared

Earth Sciences Department

Subject

GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

Approved T. Johnston

tom. johnston @tetratec h.com Digitally signed by: tom. johnston@tetratech.com DN: CN = tom. johnston@tetratech.com Date: 2016.07.14 10:17:45 -

TABLE OF CONTENTS

SECT	<u>PAGI</u>		
1.0	PURPO	2	
2.0	SCOPE		2
3.0	GLOSS	ARY	2
4.0	RESPO	NSIBILITIES AND PERSONNEL QUALIFICATIONS	3
5.0	HEALTH	H AND SAFETY	4
6.0	PROCE	DURES	6
	6.1 6.2 6.3 6.4 6.4.1 6.4.2 6.5 6.5.1 6.5.2 6.5.3 6.5.4 6.5.5 6.5.7 6.6 6.6.1 6.6.2 6.7 6.7.1 6.7.2 6.7.3	General Sampling, Monitoring, and Evacuation Equipment Calculations of Well Volume Evacuation of Static Water – Purging General Evacuation Devices Onsite Water Quality Testing Measurement of pH Measurement of Specific Conductance Measurement of Temperature Measurement of Dissolved Oxygen Measurement of Oxidation-Reduction Potential Measurement of Salinity Measurement of Turbidity Sampling Sampling Plan Sampling Methods as Related to Low-Flow Sampling Low-Flow Purging and Sampling Scope and Application Equipment Purging and Sampling Procedure	
7.0	REFERI	ENCES	28
ATTA	CHMENTS	<u>8</u>	
	A B C D	PURGING EQUIPMENT SELECTION	34 35

019611/P

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	2 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE AND APPLICABILITY

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

WARNING:

• Sample containers can be contaminated during storage if nearby volatile substances infiltrate the surrounding air and migrate into the containers. This can occur even when containers are capped. Therefore, containers that have been stored onsite for longer than 6 months should not be used.

Note: Whereas most air-borne contamination is likely to be associated with organic substances, inorganic substances such as hydrochloric acid (muriatic acid) can emit inorganic vapors that infiltrate sample containers.

3.0 GLOSSARY

<u>Conductivity</u> – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, e.g., 20.2 milliSiemens per centimeter (mS/cm) at 14 degrees Celsius (°C).

<u>Dissolved Oxygen (DO)</u> – DO concentrations in natural water (including groundwater and surface water) and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

<u>Groundwater Sample</u> – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing, and typically in a manner that is designed to represent the in-situ quality of one or more parameters of interest regarding the water in the ground.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. Also commonly referred to as redox potential or Eh. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 millivolts (mV) from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCI) solution in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCI) to 205 (3.5 Molar KCI) to 222 mV (1 Molar KCI) at 25°C and are greater at lower temperatures.

 \underline{pH} – A unitless number equal to the negative logarithm (base 10) of the hydrogen ion activity, expressed in moles per liter. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is related to the hydrogen ion

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	3 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

concentration. This is an inverse relationship, meaning that the pH decrease with increasing hydrogen ion concentration.

<u>pH Paper</u> - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

<u>Salinity</u> – The measurement of dissolved salts in a given mass of solution. Note: most field meters determine salinity automatically from conductivity and temperature. The value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol $(^{0}/_{00})$ is not the same as the percent symbol $(^{\infty})$.

<u>Specific Conductance</u> – Specific conductance is the electrical conductivity across an electrical cell of specified geometry in an electrolyte solution. The electrical current is carried by charged atoms or molecules in the solution (i.e., ions). Standard measurements are commonly made at, or normalized to, a standard temperature of 25°C. Temperature normalizations commonly are automated by the specific conductance meters used to make these measurements. Temperature compensation, however, adjusts only for changes in instrument response caused by temperature changes. The temperature compensation does not correct for changes in conductance that result from changes in ion mobility. Hence the reason most measurements are made at the standard temperature of 25°C.

<u>Turbidity</u> – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Project Manager</u> - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

<u>Site Safety Officer (SSO)</u> - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP) or equivalent. This includes but is not be limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the Field Operations Leader (FOL) on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

<u>Project Geologist/Sampler</u> - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	4 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

<u>Project Hydrogeologist</u> – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

<u>Field Operations Leader (FOL)</u> – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self-acquisition or through the management of a field team of samplers.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- OSHA 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces.
- Slips, trips, and falls.
- Cuts and lacerations.
- Traffic hazards associated with sampling in parking areas and roadways and along highways and railways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	5 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations – To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling
 with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities ASSUME THEY DO NOT SEE YOU OR MEMBERS
 OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.

	Subject	Number	Page
ı	GROUNDWATER SAMPLE	SA-1.1	6 of 36
ı	ACQUISITION AND ONSITE	Revision	Effective Date
ı	WATER QUALITY TESTING	9	7/15/2016

- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 <u>General</u>

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample.

To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

CAUTION

Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

- 1. If possible, position yourself (and the sampling equipment) upwind of the well head.
- 2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	7 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.

3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid [generally 300 milliliters (mL) per minute or greater], attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

CAUTION

For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

- 4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:
 - Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.
 - While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.
 - Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform to the guidelines in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- <u>Sample packaging and shipping equipment</u> Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.
- Field tools and instrumentation
 - Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable).
 - pH Paper.
 - Camera and film (if appropriate). Approval prior to use may be required (see SOP SA-6.3).
 - Appropriate keys (for locked wells).

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	8 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

Water level indicator and/or oil-water interface probe if separate-phase product is expected.

Pumps

- Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.
- Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).
- Pails Plastic, graduated.
- <u>Clean paper or cotton towels</u> for cleaning equipment.
- Buckets with lids for collecting purge water.
- <u>Decontamination solutions</u> Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

6.3 <u>Calculations of Well Volume</u>

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

- 1. Obtain all available information on well construction (location, casing, screen, etc.).
- 2. Determine well or inner casing diameter.
- 3. Measure and record static water level (depth below ground level or top of casing reference point).
- 4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.
- 5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- 6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where: V = Static volume of well in gallons.
T = Linear feet of water in the well.

r = Inside radius of well casing in inches.

0.163 = Conversion factor (compensates for conversion of casing radius

from inches to feet; cubic feet to gallons; and pi (π)).

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	9 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

- 1. Saturate a paper towel or clean cotton towel with deionized water.
- 2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.
- 3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc.), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Safety Data Sheet (SDS) is obtained, kept onsite at a readily available location with other SDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the Tetra Tech Health and Safety Manual (available on the Health and Safety link of the My Tetra Tech intranet site, Tetra Tech Hazard Communication Program, and OSHA Standard 29 Code of Federal Regulations [CFR] 1910.1200).

6.4 Evacuation of Static Water – Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom. Bailers are typically comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	10 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

Advantages of bailers include the following:

- There are few limitations on size and materials used.
- No external power source is needed.
- Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of crosscontamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Splashing the bailer into the water or transfer of sample may cause aeration.
- The use of a bailer does not permit constant in-line monitoring of groundwater parameters.
- Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.

Safety concerns using a bailer include the following:

- Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.
- Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.
- Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.

Control measures for these hazards are provided in Section 6.6.2.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	11 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

them. The advantage of the peristaltic pump is that it can operate from either a built in power source or a portable battery source. Safety measures associated with these pumps are provided below.

Air-Lift and Gas-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a Venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time consuming.

Compressed Gases

Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 pounds per square inch (psi). If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through an appropriate pressure-reducing regulator.
- When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.
- If the cylinder is designed to accept a valve protection cap, always keep that protection cap in place, except when the cylinder is connected for use.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	12 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

- When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).
- DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the
 protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential
 danger of an embolism.

See the project-specific HASP (or equivalent) for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of a running car to access the battery as a power source. To control these hazards:

- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	13 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the Tetra Tech Health and Safety Manual.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ORP
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	14 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

6.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 CFR 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain SDSs from the manufacturer for the specific buffer solutions (see Section 4 of the Tetra Tech Health and Safety Manual regarding the Hazard Communication Program).
- pH indicator paper to cover the pH range 2 through 12.
- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- 1. Inspect the instrument and batteries prior to initiation of the field effort.
- 2. Check that the buffer solutions are used for field calibration prior to their expiration dates. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- 3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	15 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

- 4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.
- 5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.
- 6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).
- 7. Rinse the electrode(s) with deionized water.
- 8. Store the electrode(s) in an accordance with manufacturer's instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, or 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown, then the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

- 1. Collect a small portion of sample into a clean container.
- 2. Dip the pH paper into this small portion of sample.
- 3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.
- 4. Record the pH value from the chart on the sample log sheet.
- 5. Discard the used pH paper as trash.
- 6. Discard the small volume of sample that was used for the pH measurement with the other investigativederived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	16 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

Specific conductance at 25°C is used as a standard of comparison for different water sources as conductivity changes with temperature. It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form. If a sample cannot be cooled or warmed (as appropriate) to 25°C, this should be noted in the field documentation

6.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

1. Check batteries and calibrate instrument before going into the field.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	17 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

- 2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
- 3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.
- 4. Immerse the electrode in the sample and measure the conductivity.
- 5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
- 6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

- 1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.
- 2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

- 1. Calibrate the instrument according to manufacturer's recommendations prior to use.
- 2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	18 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical, and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 Principles of Equipment Operation

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects, but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	19 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

- 1. Check the DO meter batteries before going to the field.
- 2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- 3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly airsaturated water sample of known temperature.
- 4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
- 5. Rinse the probe with deionized water.
- 6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.
- 7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.
- 8. Rinse the probe with deionized water.
- 9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	20 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

- 1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.
- 2. Thoroughly rinse the electrode with deionized water.
- 3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.
- 4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater).

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	21 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision	Effective Date
WATER QUALITY TESTINO	9	7/15/2016

Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).
- Calibration solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

- 1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
- 2. Check batteries and calibrate the meter before going into the field.
- 3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
- 4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.
- 5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
- 6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 **General**

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	22 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter, but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (preferably a stand-alone meter such as a LaMotte 2020) that calibrates easily using test cells with standards such as 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an inline sample chamber (e.g., YSI 600 series and Horiba U-22). The range of calibration standards should bracket the measured sample turbidities.
- Calibration solution and sample tubes, as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.7.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization shall be done according to manufacturer's instructions):

- 1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
- 2. Check batteries and calibrate the instrument before going into the field.
- 3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.
- 4. When using the YSI 600 and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.
- 5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, aligning the arrow on the cap of the test cell to the arrow on the meter, and close the lid.
- 6. Immerse the electrode in the sample and measure the turbidity.
- 7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- 8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- 9. Rinse the electrode or test cell with deionized water.

	Subject	Number	Page
	GROUNDWATER SAMPLE	SA-1.1	23 of 36
	ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision	Effective Date
ı	WATER GOALITT TEOTING	9	7/15/2016

6.6 <u>Sampling</u>

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- · Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated. Refer to the project-specific HASP (or equivalent) for appropriate information and direction on air monitoring requirements.
- Sample preservation requirements.
- Work schedule.
- · List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.
- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP (or equivalent), indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP (or equivalent) author.
- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow.
 Where sampling teams are made up of personnel from multiple locations, personal sampling
 experiences may vary. Therefore, the FOL shall review project-specific requirements, SOPs, and
 protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are being
 completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like

ı	Subject	Number	Page
ı	GROUNDWATER SAMPLE	SA-1.1	24 of 36
	ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

to sun themselves on concrete well pads. Follow provisions in the project-specific HASP (or equivalent) and/or Tetra Tech Health and Safety Manual for addressing natural hazards.

- 2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases form contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:
 - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.
 - DO NOT place your face or any other part of your body over the well when opening because this
 may place you in a strike zone.
 - Open the well cover at arms' length, then step away and allow the well to off gas and stabilize.

Follow directions provided in the project-specific HASP (or equivalent), Work Plan, and/or SAP pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the sampler during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP or equivalent).

- 3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.
- 4. Calculate volume of well water to be removed as described in Section 6.3.
- 5. Select the appropriate purging equipment (see Attachment A) or as designated within the governing Work Plan/SAP. If an electric submersible pump with packer is chosen, go to Step 10.
- 6. Lower the purging equipment or intake into the well to a short distance below the water level or midscreen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.
- 7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.

S	Subject	Number	Page
	GROUNDWATER SAMPLE	SA-1.1	25 of 36
	ACQUISITION AND ONSITE	Revision	Effective Date
	WATER QUALITY TESTING	9	7/15/2016

- 8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
- 9. Purge a minimum of three to five well casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.
- 10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.
- 11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
- 12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.
- 13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.
- 14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.
- 15. Process sample containers as described in SOP SA-6.1.
- 16. Decontaminate equipment as described in SOP SA-7.1.

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds [VOCs and SVOCs], pesticides, polychlorinated biphenyls [PCBs], metals, and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	26 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Interface probe.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic vapors per the HASP (or equivalent).

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	27 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

6.7.3 Purging and Sampling Procedure

- 1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP or equivalent (typically with a PID or FID).
- 2 Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.
- 3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.
- 4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.
- 5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.
- 6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rate as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease or the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.
- 7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
- 8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.
- 9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.
- 10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	28 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

- 11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:
 - pH ±0.2 standard units
 - Specific conductance ±10%
 - Temperature ±10%
 - Turbidity less than 10 NTUs
 - DO ±10%
- 12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.

NOTE: VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

- 13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:
 - Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.
 - Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.
 - Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.
 - Prepare samples for shipping as per SOP SA-6.1.

7.0 REFERENCES

American Public Health Association, 1989. <u>Standard Methods for the Examination of Water and Wastewater</u>, 17th Edition, APHA, Washington, D.C.

Barcelona, M. J., J. P. Gibb and R. A. Miller, 1983. <u>A Guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling.</u> ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

Johnson Division, UOP, Inc. 1975. <u>Ground Water and Wells, A Reference Book for the Water Well Industry.</u> Johnson Division, UOP, Inc., Saint Paul, Minnesota.

Nielsen, D. M. and G. L. Yeates, 1985. <u>A Comparison of Sampling Mechanisms Available for Small-Diameter Ground Water Monitoring Wells.</u> Ground Water Monitoring Review 5:83-98.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	29 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. <u>Manual of Ground Water Sampling Procedures.</u> R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

- U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.
- U.S. EPA, 1980. <u>Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities.</u> Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.
- U.S. EPA, 1992. Specifications and Guidance for Contaminant-Free Sample Containers. EPA-540/R-93/051.
- U.S. EPA, 1999. <u>Recommended Procedure for Low Flow Purging and Sampling of Groundwater Monitoring Wells.</u> U.S. Environmental Protection Agency, Region 3 Bulletin No. QAD023.
- U.S. Geological Survey, 1984. <u>National Handbook of Recommended Methods for Water Data Acquisition</u>, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	30 of 36
ACQUISITION AND ONSITE	Revision	Effective Date
WATER QUALITY TESTING	9	7/15/2016

ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	Х	Х	Х	X	Х			
	Water Level >25 feet	Х			Х				
2-Inch	Water level <25 feet	Х	Х	Х	Х	Х	х		
	Water Level >25 feet	X			Х		х		
4-Inch	Water level <25 feet	X	Х	Х	Х	Х	X	X	Х
	Water Level >25 feet	X			Х		X	X	Х
6-Inch	Water level <25 feet				Х	Х		Х	Х
	Water Level >25 feet				Х			х	х
8-Inch	Water level <25 feet				Х	Х		х	х
	Water Level >25 feet				Х			Х	Х

ATTACHMENT A
Purging and Sampling Equipment Selection (Updated July 2016)

Manufacturer	Model Name/ Number	Principle of Operation	I/E¹	Maximum Outer Diameter (OD)/ Length (L) ²	Construction Materials ³ (with Lines and Tubing)	Lift Range (Feet)	Delivery Rates or Volumes ⁴	Main Source(s) of Information ⁵	Comments
	Purging/Sampling E	quipment							
GeoTech Environmental Equipment, Inc.		Porlable; peristaltic vacuum (suction) or pressure - reversible pump	Е	3.5" x 8" x 8"	Not applicable (NA)	0 - 27	0 - 1,000 mL/min	Mfg/Pine	Variable speed; operate with 12 volt (V) direct current (DC) or 120V alternating current (AC) power source.
Grundfos Pumps Corporation	Redi-Flo2	Portable; submersible pump	ı	1.8" OD x 11" L	SS; PTFE (i.e., Teflon®)	0 - 250	100 mL/min to 9 gpm	Pine/PNNL	Variable speed (adjustable flow rate); ideal for purging or sampling.
QED Environmental Systems	Sample Pro	Portable; bladder pump (positive displacement)	ı	1.75" OD x 12" L	SS: PTFE or PE disposable bladder	0 - 250	0 - 800 mL/min	Mfg.	First pump developed specifically to bring the advantages of low-flow sampling to sites with non-dedicated pumps.
QED Environmental Systems	Well Wizard	Dedicated; bladder pump (positive displacement)	ı	1.66" OD x 41" L	SS; PTFE bladder, HDPE, PP	0 - 1,000	0 - 2,000 mL/min	Pine/PNNL	Ideal for deep well applications and long- term monitoring. Available in a variety of sizes and materials.
Less Commonly U	Jsed Purging/Samp	ling Equipment							
Bennett Sample Pumps, Inc.	Bennett 1800-8	Portable; piston pump (positive displacement)	I	1.8" OD x 23.625" L	SS: PTFE, PP, Nylon	0 - 1,000	100 mL/min to 2.6 gpm	Mfg./PNNL	Variable speed (adjustable flow rate); ideal for purging or sampling. Discharge rates are difficult to control.
Cole-Parmer Inst. Co.	Masterflex 7571-00	Porlable; peristaltic vacuum (suction) or pressure - reversible pump	Е	16" x 10.25" x 11"	NA	0 - 27	0.06 - 680 mL/min	Mfg/Pine	Peristaltic pumps are not recommended for sampling volatile organic compounds (VOCs).
Fultz Pumps, Inc.	Fultz SP300	Porlable; gear driven pump (positive displacement)	ı	1.75" OD x 9.16" L	SS; PTFE gears, Viton®	0 - 200	100 mL/min to 2.4 gpm	Mfg./PNNL	Variable speed (adjustable flow rate); ideal for purging or sampling. Low extraction rates are difficult to control.
GeoTech Environmental Equipment, Inc.	Keck SP12	Porlable; progressive cavity pump (positive displacement)	I	1.75" OD x 25" L	SS; EPDM stator, PE	0 - 150	100 mL/min to 1.2 gpm	Mfg./PNNL	Variable speed (adjustable flow rate); ideal for purging or sampling. Low extraction rates are difficult to control.
GeoTech Environmental Equipment, Inc.	SS Geosub	Porlable; single speed submersible purge pump	I	1.75" OD x 13.2" L	SS; PTFE, Viton®	0 - 200	low flow to 10 mL/min	Mfg/Pine	Only 12V SS pump with Teflon® cable according to GeoTech brochure.
GeoTech Environmental Equipment, Inc.	NA	Porlable; centrifugal purge pump		NA	NA	0 - 55	2.5 gpm max.	Mfg.	Not recommended for sampling.
GeoTech Environmental Equipment, Inc.	Various	Porlable; bladder pump (positive displacement)	ı	0.675-1.66" OD	SS or PVC; PTFE or PE bladder; FEP or PE tubing	0 - 200 SS; 0 - 250 PVC	NA	Mfg.	Various sizes are available. Pump is also available in PVC instead of SS.
GeoTech Environmental Equipment, Inc.	Bailer	Porlable; grab (positive displacement)	I	Various sizes	Various materials - HDPE, PVC, SS, or fluoropolymer	No limit	NA	Mfg.	Low cost, easy operation; potential churning could increase turbidity. Typically a last-resort option.
Grundfos Pumps Corporation	Redi-Flo3	Portable; submersible pump	ı	2.9" OD	SS; PVDF, Viton®, Tefzel®	0 - 360	8 gpm max.	Pine/PNNL	Not designed for low flow use.
Grundfos Pumps Corporation	Redi-Flo4	Portable; submersible pump	ı	3.8" OD	SS; PTFE	0 - 600	100 mL/min to 10 gpm	Pine/PNNL	Variable speed (adjustable flow rate); ideal for purging or sampling.
КҮВ	HydroStar™	Porlable; single-action piston pump (positive displacement)	I	1.66" OD	SS; PTFE	0 - 400	100 mL/min to 5 gpm	Mfg./PNNL	Variable speed (adjustable flow rate); ideal for purging or sampling. Discharge rates are difficult to control.

Subject

GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

Revision

Number

Page

31 of 36

Effective Date 7/15/2016

ATTACHMENT A
Purging and Sampling Equipment Selection (Updated July 2016)

Manufacturer	Model Name/ Number	Principle of Operation	I/E¹	Maximum Outer Diameter (OD)/ Length (L) ²	Construction Materials ³ (with Lines and Tubing)	Lift Range (Feet)	Delivery Rates or Volumes ⁴	Main Source(s) of Information ⁵	Comments
Landtec North America	Nu-Matic 4	Dedicated; pneumatic displacement pump	ı	3.5" OD x 43.25" L	ss	0 - 275	10 gpm max.	Pine	Float activated, fully automatic; ideal for the harsh environment of landfill conditions.
ProActive Environmental Products		Portable; Low Flow pumps available in a variety of sizes	1	1.82" OD x 7.5" L	SS; PE	0 - 120	10 mL/min to 3.5 gpm	Pine/GeoTech	12V DC - designed for continuous purging and low flow sampling.
QED Environmental Systems	Eliminator	Porlable; bladder pump (positive displacement)	-	3" OD x 40" L	SS; PTFE or elastomer bladder, Q-Tal®, Viton®	0 - 230	6 gpm max.	Pine	High capacity, designed for light non- aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) removal in 4" wells.
QED Environmental Systems	Pulse Pump	Portable; pneumatic displacement pump	ı	1.66" OD x 20" L	SS; PTFE	0 - 230	2 gpm max.	Pine	Especially suited for DNAPL recovery. Requires compressed air, external timer.
Solinst Canada Ltd.	404 WaTerra	Porlable; inertial reciprocating pump (positive displacement)	1	Various sizes	SS or Delrin® footvalve; HDPE tubing	0 - 200	2 gpm max.	Pine	Low cost, easy operation; potential chuming could increase turbidity. Simple alternative to a bailer.
Solinst Canada Ltd.	407 Integra	Portable; bladder pump	ı	1" or 1.66" OD	SS or PVC; FEP bladder (disposable PE available)	SS - 0 - 500 PVC - 0-100	3.3 L/min at 150'	Pine	Regular or low flow applications.
Solinst Canada Ltd.	408 DVP	Portable; pneumatic drive pump	ı	1.66" OD x 24" L	SS or PVC; FEP bladder	SS - 0 - 500 PVC - 0-100	3.3 L/min at 150'	Pine	Regular or low flow applications - can deliver high flow rates.
Solinst Canada Ltd.	408M DVP	Porlable; micro pneumatic drive pump	ı	0.375" OD	FEP tubing	0 - 240	20 - 150 mL/min	Pine	Uses coaxial FEP tubing, easy to transport and install; ideal for low flow and narrow down-hole applications.
Solinst Canada Ltd.	410	Portable; peristaltic (negative pressure) pump	Е	13" x 5" x 6"	NA	0 - 27	120 - 3,500 mL/min	Pine	Ideal for vapor sampling, water from shallow wells, or surface water.
TIMCO Mfg. Co., Inc.	Bailer	Porlable; grab (positive displacement)	-	Various sizes	PVC, PP, others	No limit	250 mL/foot of bailer	Old SOP	Other sizes, materials, models available; optional bottom-emptying device available, no solvents used.
No-Purge Samplir	ng Equipment (Avai	lable Options on Some Projects)							
Amplified Geochemical Imaging (AGI), LLC	AGI Universal Sampler (formerly Gore-Sorber™ Module)	Passive container; diffusion-type sampler	ı	0.25" OD x 8" L	Waterproof, vapor- permeable GORE-TEX™ polymer membrane of expanded PTFE	0 - 32	NA	ITRC PSC-5	Demonstrated to be applicable to a variety of (but not all) VOCs, semivolatile organic compounds (SVOCs), and polycyclic aromatic hydrocarbons (PAHs); not designed for inorganics.
Geolnsight, Inc.	HydraSleeve™	Passive container; grab-type sampler	ı	1.5-2.6" OD x 30" L	PE tubing with PE reed- valve	No limit	650 - 1,250 mL	ITRC PSC-5	Demonstrated to be applicable to a variety of VOCs and inorganics.
Mutiple Manufacturers	RPPS	Rigid Porous Polyethylene Sampler (RFPS); diffusion-type sampler	1	1.5" OD x 5" L	Rigid PE tube - thin sheets of foamlike porous PE with a Delrin* plug	No limit	80 - 100 mL	ITRC PSC-5	Developed by Don Vroblesky (USGS). Demonstrated to be applicable to a variety of water-soluble organics and inorganics.
Mutiple Manufacturers	PDB	Passive Diffusion Bag (PDB) Sampler; diffusion-type sampler	ı	1.2-2" OD, 18-24" L	LDPE with HDPE cap; some vendors use other materials and sizes	No limit	75 - 350 mL	ITRC PSC-3	Developed by Don Vroblesky (USGS) and Thomas Hyde (GE). Demonstrated to be applicable to a variety of (but not all) VOCs; not for inorganics.

Subject

GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

Revision

Number

Page

32 of 36

Effective Date 7/15/2016

ATTACHMENT A

Purging and Sampling Equipment Selection (Updated July 2016)

Manufacturer	Model Name/ Number	Principle of Operation	I/E¹	Maximum Outer Diameter (OD)/ Length (L) ²	Construction Materials ³ (with Lines and Tubing)	Lift Range (Feet)	Delivery Rates or Volumes ⁴	Main Source(s) of Information ⁵	Comments
ProHydro, Inc.	Snap Sampler™	Pneumatic actuator; grab-type sampler	3	1.7-3.4" OD x 19- 22+" L	Acetal with PFA-coated SS spring; optional SS weight; 40 mL glass vials or 125- 350 mL PP bottles	0 - 2,500	40 - 1,400 mL	ITRC PSC-5	Demonstrated to be applicable to a variety of VOCs and inorganics. Up to 4 bottles may be employed together.
Multi-Level Groundwater Monitoring System (MLS) (Used on Some Projects based on Stakeholder Agreement)									
FLUT, Ltd. Co.	Water FLUTe™	Dedicated; gas drive sampling, liner seals entire borehole wall.	1	Various sizes	NA	NA	NA	Mfg.	Practical to collect large volumes; can use low flow method; minimizes investigation-derived waste (IDW); proven technology.
Solinst Canada Ltd.	Continuous Multichannel Tubing (CMT)	Dedicated; 3 or 7-channel tubing designed to isolate and monitor depth discrete zones.	1	Up to 7 ports	NA	NA	NA	Mfg.	Low cost and easy to install; ideal for shallow applications; single tube for effective sealing.
Solinst Canada Ltd.	Waterloo	Dedicated; double valve or bladder pump sampling; packers separate ports at multiple depths.	1	Various sizes	NA	NA	NA	Mfg.	Practical to collect large volumes; can use low flow method; minimizes IDW; proven technology.
Schlumberger	Westbay	Dedicated; packers separate ports at multiple depths.	_	Various sizes	NA	NA	NA	Mfg.	Transducer and sampler are on a wire line; minimizes IDW; proven technology. Low long-time maintenance costs.

Subject

GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

Revision

Effective Date 7/15/2016

33of 36

Footnotes:

- 1 I/E Internal (I) or external (E) to the well.
- 2 For external pumps, the size is given in three dimensions (i.e. length, width, height), for internal pumps, the size is given in outside diameter (OD) and length (L) (in inches).

 3 Construction materials for pumps and associated equipment include: SS = stainless steet; PTFE = polytetrafluoroethylene; HDPE = high density polyethylene; PP = polypropylene; PE = polytetrafluoroethylene; HDPE = high density polyethylene; PP = polytetrafluoroethylene; PP = polytetrafluoroethylene;
- PVC = polyvinyl chloride; FEP = fluorinated ethylene propylene; PVDF = polyvinylidene difluoride; EPDM = ethylene-propylene-diene elastomr; LDPE = low density polyethylene; PFA = perfluoroalkoxy.
- 4 Rate or volume abbreviations: mL/min = milliliters per minute; gpm = gallons per minute; L/min = liters per minute; max. = maximum; mL = milliliters.
- 5 Sources of information include specification sheets from the manufacturer (i.e., "Mfg."); equipment rental company websites Pine Environmental (www.pine-environmental.com); GeoTech (www.geoenvtech.com); and guidance documents from Pacific Northwest National Laboratory (PNNL) (i.e., PNNL-13690) and Interstate Technology & Regulatory Council (ITRC) (i.e., PSC-3 and PSC-5 available at www.itrcweb.org).

Subject

GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

Number	Page
SA-1.1	34 of 36
Revision	Effective Date
9	7/15/2016

ATTACHMENT B GROUNDWATER SAMPLE LOG SHEET (EXAMPLE)

TŁ Te	etra Tech	GROUN	DWAT	ER SA	MPLE LC	G SHEE	Т	_	
Project Site Name: Project No.: [] Domestic Well Data [x] Monitoring Well Data [] Other Well Type: [] QA Sample Type:					-	Sample Sample Sample C.O.C. I Type of [X] Lo			
SAMPLING DAT	TA:		1		and almost and	2112			
Date:		Color	pН	S.C.	Temp.	Turbidity	DO	ORP	Other
Time: Method:		Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
PURGE DATA:								L	1000
Date:		Volume	pН	s.c.	Temp. (C)	Turbidity	DO	ORP	Other
		volume	рп	5.0.	Temp. (C)	Turblaity	- 50	UNP	Other
Method:	(<u> </u>	-	OEE.	LOW ELO	W PURG	E DATA S	L	
Monitor Reading				SEE	LOW FLO	VV FONGI	DAIAS	T	
Well Casing Dia	meter & Material		\vdash		-				
Type:					-				
Total Well Depth			\vdash						
Static Water Lev			$\overline{}$		-				
One Casing Volu	ume(gal/L):								
Start Purge (hrs)):								
End Purge (hrs):									
Total Purge Time	e (min):				<u> </u>				
Total Vol. Purge								301	
Including the second se	ECTION INFORMA	TION:				Container Re			
	Analysis			vative		Collected			
					-				
-					 				

					-				
OBSERVATION	S / NOTES:								
l									
l									
l									
l									
Circle if Applica	able:					Signature(s):		
MS/MSD	Duplicate ID No.:			e_UUuusuesuu	Later to the second	1	,-		
MONIOD	Dapineate ID 110								

Subject	Number	Page
GROUNDWATER SAMPLE	SA-1.1	35 of 36
ACQUISITION AND ONSITE WATER QUALITY TESTING	Revision 9	Effective Date 7/15/2016

ATTACHMENT C EQUIPMENT CALIBRATION LOG (EXAMPLE)

TŁ	Tetra Tech	EQUIPMENT CALIBRATION LOG						
PROJ	ECT NAME :			_	INSTRUMEN	IT NAME/MO	DEL:	
SITE	NAME:			-	MANUFACT	URER:		
PROJ	ECT No.:			SERIAL NUMBER:				
Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Pre- calibration	t Settings Post- calibration	Instrument Pre- calibration	Post- calibration	Calibration Standard (Lot No.)	Remarks and Comments
							-	

019611/P Tetra Tech, Inc.

		ject
ATT	ACQUISITION AND ONSITE WATER QUALITY TESTING	GROUNDWATER SAMPLE
ATTACHMENT D (EXAMPLE) LOW FLOW PURGE DATA SHEET	Revision 9	Number SA-1.1
OF	Effective Date 7/15/2016	Page 36 of 36

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: PROJECT NUMBER:	WELL ID.: DATE:	

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments
		-								
		<u> </u>								
		-								
									_	
										
		-					<u> </u>			

SIGNATURE(S):	PAGE	OF_



STANDARD OPERATING PROCEDURE

Number SA-1.8	Page 1 of 13
Effective Date 05/18/2018	Revision 4

Applicability

Tetra Tech, Inc., NUS Operating Unit

Prepared

Earth Sciences Department

Subject

SAMPLE ACQUISITION FOR PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES (PFAS) ANALYSIS

Approved

T. Johnston

TABLE OF CONTENTS

SECT	<u>TION</u>	<u>PAGE</u>
1.0	PURPOSE	2
2.0	SCOPE AND APPLICABILITY	2
3.0	BACKGROUND	2
4.0	DEFINITIONS	3
5.0	SAFETY PRECAUTIONS	4
6.0	PERSONNEL RESPONSIBILITIES, QUALIFICATIONS, AND TRAINING	4
7.0	PROCEDURES	5
	7.1 SELECTION OF EQUIPMENT	
	7.3 GROUNDWATER SAMPLE ACQUISITION	8
	7.4 SOIL SAMPLE ACQUISITION	
	7.5 SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION	
	7.7 FIELD REAGENT BLANK COLLECTION	
	7.8 DISPOSAL OF INVESTIGATION-DERIVED WASTE POTENTIALLY CONTAIN	_
	PFAS	
8.0	REFERENCES	12

Number SA-1.8	Page 2 of 13
Revision 4	Effective Date 05/18/2018

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the methods and protocols to be used for collecting and handling samples to be analyzed for per- and polyfluoroalkyl substances (PFAS). PFAS are present in many consumer products including some typical sampling equipment and are widely present in the environment.

Low regulatory criteria and high cross-contamination potential require special precautions to be implemented to avoid compromising sample integrity. Instructions are provided herein for collection of environmental samples without contaminating them. This SOP is designed to supplement but not replace existing sampling SOPs SA-1.1, SA-1.2, SA-1.3, SA-1.7, and SA-5.1. In addition, some clients and/or projects may have specific PFAS-related sampling requirements that extend beyond the procedures described in this SOP. Such additional requirements typically are documented in work plans or similar documents.

2.0 SCOPE AND APPLICABILITY

This document provides information on selection of proper sampling equipment and techniques for groundwater, surface water, sediment, soil, and water supply sampling for PFAS analysis. Sampling of air or biota is not addressed in this SOP, but similar principles would apply for those media.

3.0 BACKGROUND

PFAS have been used since the 1940s as manufacturer-applied oil and water repellants on products such as clothing, upholstery, paper, and carpets and in making fluoropolymers for non-stick cookware. They are found in textiles and leather products, mist suppressants for metal plating, materials used in the photography industry, photolithography, semi-conductors, paper and packaging, coatings, cleaning products, pesticides, and cosmetics. They have been used in well-known consumer products including Teflon, StainMaster, Scotchgard, and GoreTex. In the 1960s, aqueous film-forming foam (AFFF) containing PFASs was developed for fighting flammable liquid fires, particularly petroleum-fueled (Class B) fires (ATSDR, 2009). The two most researched and most prevalent PFAS in the environment are perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) (ATSDR, 2009).

Military uses of PFAS have been primarily related to fire fighting and electroplating. AFFF meeting MIL-F-24385 specifications was developed by various manufacturers for use in extinguishing fires at military bases, airports, commercial facilities, and fire-fighting training facilities throughout the United States. Beginning in the late 1960s the United States Department of Defense (DoD) used large quantities of AFFF for shipboard and shore facility fire-suppression systems, on fire-fighting vehicles, and at fire-training facilities. AFFF concentrate that contains PFAS may still be in use at DoD facilities, and large quantities of AFFF may have been released to the environment at some facilities.

PFAS are persistent in the environment, tend to bioaccumulate, and demonstrate toxicity in laboratory animals, enough to raise concerns about their presence in the environment. Some areas where PFAS may have been released to the environment include the following:

- Fire-fighting training areas
- Areas where fire-fighting products/materials are stored (e.g., fire stations)
- Aircraft crash sites
- Refineries
- DoD sites/military bases
- Landfills (leaching from consumer products)
- Biosolids land applications

Number	Page
SA-1.8	3 of 13
Revision 4	Effective Date 05/18/2018

- Rail yards
- Textile/carper manufacturing sites
- Septic systems
- Metal coating and plating facilities
- Water treatment systems and receiving water bodies
- Airport hangars and other facilities storing fire-fighting foams
- Chemical facilities, especially fluorochemical manufacturing, use, and disposal facilities

PFAS are ubiquitous in consumer products and are present in or on some materials used in environmental sampling (e.g., Teflon tubing, waterproof logbooks, and GoreTex field clothing). Laboratory detection limits are low for PFAS, and contact of sample material or sampling equipment with any one of the multitude of PFAS sources could result in detectable contamination. In addition, PFAS tend to adsorb to glass and some plastics, so certain glass or plastic sample collection containers are inappropriate for use in PFAS sample collection. Adsorption to sample containers may result in a low bias for measured PFAS concentrations.

Collection and analysis of quality control blanks is an important aspect of verifying that samples have not been contaminated during sample collection and handling. Use of additional blanks or blanks of a different type than usual may be required in some circumstances, and the governing project planning documents should be consulted. Consult Section 7.7 of this SOP for instructions regarding collection of field reagent blanks (FRBs).

4.0 DEFINITIONS

AFFF - Aqueous film-forming foam.

<u>Emerging Contaminant</u> – An emerging contaminant is a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environment or by a lack of published health standards (U.S. EPA, 2014). A contaminant may also be "emerging" because a new source or a new pathway for human exposure has been discovered or a new detection method or treatment technology has been developed (DoD, 2011).

<u>FRB</u> – Field Reagent Blank. A blank sample prepared in the field by transferring laboratory-supplied, chemically preserved, "PFAS-free" deionized water to an empty, laboratory-supplied, collection bottle. FRBs are typically analyzed only for PFAS and are treated as site samples in all respects, including shipment to the sampling site, exposure to sampling site conditions, storage, preservation, and all PFAS analytical procedures. The purpose of FRBs is to indicate whether PFAS measured in corresponding site samples may have been introduced during sample collection and handling.

<u>PFAS</u> – Per- and Polyfluoroalkyl Substances. A reference term currently in use, replacing "PFCs" in recent scientific and other technical literature. The term is inclusive of both perfluorinated chemicals like PFOA and PFOS and polyfluoroalkyl substances like fluorinated telomers.

<u>PFCs</u> – Perfluorinated Compounds or Chemicals. PFCs are a family of man-made chemicals that have been used for commercial, industrial, and military applications because they resist thermal degradation and repel oil, stains, grease, and water.

<u>PFOA</u> – Perfluorooctanoic Acid. PFOA is used as an aqueous dispersion agent (surfactant) and in the manufacture of fluoropolymers (including Teflon) used in industrial components such as electrical wire casings, fire- and chemical-resistant tubing, and plumbing seal tape. PFOA is used in surface treatment products (e.g., paints) to impart oil, stain, grease, and water resistance. PFOA can also be produced by the breakdown of some fluorinated telomers.

Number	Page
SA-1.8	4 of 13
Revision 4	Effective Date 05/18/2018

<u>PFOS</u> – Perfluorooctane Sulfonate. PFOS was a key ingredient in Scotchgard and used in the manufacture of Class B AFFF used per DoD military specifications. Phase out of AFFF by 3M occurred in 2002.

5.0 SAFETY PRECAUTIONS

Sample acquisition activities shall be conducted in accordance health and safety requirements identified in the project-specific Health and Safety Plan (HASP), Accident Prevention Plan (APP), and corporate health and safety policies. Alteration may be necessary to allow sample collection without cross contamination as dictated by site-specific conditions.

Caution

The use of personal protective equipment (PPE) containing PFAS (e.g., some insect repellants, sunscreens, traffic safety vests, etc.) should be avoided if possible or, if deemed necessary to control hazards, should be carefully considered as they can pose a potential cross-contamination risk for samples. Extra care (e.g., changing outer gloves) must be exercised to ensure that PFAS is not transferred directly or indirectly from PPE to samples or sample containers.

The Tetra Tech Project Manager (PM), in coordination with the Tetra Tech NUS Operating Unit Health and Safety Group, shall ensure that the development of project-specific plans balances the need to control exposure to safety hazards as well as address PFAS contamination risks.

6.0 PERSONNEL RESPONSIBILITIES, QUALIFICATIONS, AND TRAINING

<u>Project Manager (PM)</u> – The PM along with the management team are responsible for determining sampling objectives, initial sampling locations, and field procedures used in the collection of samples of environmental media. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the PM is responsible for selecting and detailing the specific sampling techniques and equipment to be used and for providing detailed input in this regard to the project planning documents. The PM has the overall responsibility for ensuring that sampling activities are properly conducted by appropriately trained staff.

<u>Site Safety and Health Officer (SSHO)</u> – The SSHO (or a qualified designee) is responsible for providing the technical support necessary to implement the project HASP, APP, or equivalent. The SSHO or SSHO designee may also be required to advise the Field Operations Leader (FOL) on safety-related matters regarding sampling, such as measures to mitigate potential hazards, hazardous objects, or conditions.

<u>Project Geologist/Sampler</u> – The project geologist/sampler is responsible for proper acquisition of samples in accordance with this SOP and other project-specific governing documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

<u>Field Operations Leader (FOL)</u> – This individual is primarily responsible for the execution of the field sampling program in accordance with the project planning documents. This is accomplished through management of a field sampling team for the proper acquisition of samples.

Personnel implementing this SOP must read and understand this SOP prior to collection of samples designated for PFAS analysis.

Number SA-1.8	Page 5 of 13
Revision 4	Effective Date 05/18/2018

7.0 PROCEDURES

The following sampling procedure establishes requirements for collection of samples designated for PFAS analysis while minimizing potential cross contamination of the samples and other materials.

7.1 <u>Selection of Equipment</u>

It is important to research available equipment and materials at the project planning stage to avoid last-minute problems in the field, for example, ensuring compatibility of high-density polyethylene (HDPE) tubing with fittings for use in a peristaltic or other pump, or ensuring that equipment (e.g., a bladder pump) does not contain Teflon.

Sampling Equipment:

Note: PFAS cross-contamination of samples can be minimized through decontamination or conditioning of equipment left in a well. Use of dedicated equipment also is helpful so that handling during decontamination is unnecessary.

- Decontamination All reusable equipment used in sample acquisition should be adequately decontaminated prior to use. Consult Safety Data Sheets (SDSs) to verify that soaps or detergents used in decontamination do not contain fluorosurfactants.
- Unless project requirements indicate otherwise, use sampling equipment made of stainless steel, acetate, silicone, or HDPE. This applies to tubing, pumps and pump components, tape for plumbing fittings, trowels, mixing bowls, or other equipment that could contact the sample media. Gasket and O-ring components of sampling equipment may also contain fluoropolymers.

Note: PFAS on purchased or rented items is likely to occur predominantly in newly manufactured or rented items treated with chemicals containing PFAS. Therefore, all rental equipment that will make direct contact with the material being sampled must be thoroughly decontaminated prior to use, especially if the equipment items are new. Be cognizant of the potential for continued leaching of PFAS or other chemicals — even after decontamination.

- During sample handling, mobilization, and demobilization, avoid using sampling equipment that includes or contains polyvinylidene fluoride (PVDF) or contains "fluoro" in the name such as:
 - Polytetrafluoroethylene (PTFE)
 - Teflon (DuPont brand name)
 - Fluorinated ethylene propylene (FEP)
 - Ethylene tetrafluoroethylene (ETFE).
- Use products that are not made of low-density polyethylene products (LDPE) if contamination from those products can be transferred to environmental samples or QC samples.
- For collecting drinking water samples to be analyzed using United States Environmental Protection Agency (U.S. EPA) Method 537, use polypropylene sample bottles with a polypropylene screw cap; for all other samples, use HDPE containers with unlined plastic screw caps.

Non-Sampling Field Equipment:

 Non-waterproof loose-leaf paper or notebooks are acceptable. Avoid using waterproof field books or paper during sampling activities. Do not use plastic clipboards, binders, or spiral hard-cover notebooks that may be coated; use Masonite or aluminum clipboards instead.

Subject
SAMPLE ACQUISITION FOR
PERFLUOROALKYL AND
POLYFLUOROALKYL SUBSTANCES
(PFAS) ANALYSIS

Number	Page
SA-1.8	6 of 13
Revision 4	Effective Date 05/18/2018

- Avoid using Post-it notes or similar removable notes during sample handling or mobilization/demobilization activities.
- Use ballpoint pens or pencils for note taking and sample bottle labeling. Avoid using Sharpies or similar indelible markers.
- Avoid the use of aluminum foil.

Field Personnel Clothing and Protective Gear:

- Wear clothing that has been washed at least six times without fabric softener to remove possible stain-resistant coatings. Clothing made of natural fibers such as cotton is preferred to other fabrics. Protective clothing must be washed in accordance with manufacturer recommendations to ensure that the protective properties necessary to control safety hazards (e.g., fire-retardant clothing) are not compromised.
- Avoid unnecessary contact with upholstery in vehicles because many such fabrics may be treated
 with stain-resistant materials that could contain PFAS. Typically, rental vehicles are newer and more
 likely to pose a contamination risk to samples. Well-washed towels or rags may be placed on the
 seats to prevent contact with car seats and other materials that could transfer PFAS to clothing worn
 by samplers. If practical, cover clothing and skin that has been in contact with such upholstery with
 non-fluorinated clothing.
- During wet weather, use rain gear made from polyurethane or wax-coated materials.
- Avoid wearing water-resistant (e.g., Gore-Tex or similar material) clothing or footwear (e.g., boots) immediately prior to or during sample collection and management.
- Avoid wearing coated Tyvek or similar coated PPE suits.
- Wear un-powdered nitrile gloves at all times while collecting and handling samples, and change gloves often. Anecdotal evidence indicates that changing gloves is one of the most effective methods of reducing or eliminating sample contamination potential; therefore, change to a new pair of gloves prior to collecting each sample.
- Avoid wearing cosmetics, shampoos, hair conditioners, moisturizers, hand cream, or other similar personal care products on the day of sampling.
- As necessary, use sunscreens and insect repellants that are made with 100-percent natural
 ingredients and that the Air Force Civil Engineer Center has identified as acceptable for use. These
 products must be used in accordance with manufacturer recommendations and in
 combination with controls in the project-specific HASP, APP, and corporate health and safety
 policies. Multiple applications of these products per work shift may be required to ensure
 their effectiveness.
 - Sunscreens: Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss My Face, baby sunscreens that are "free" or "natural."
 - Sunscreen and insect repellant: Avon Skin So Soft Bug Guard Plus SPF 30 Lotion

Number SA-1.8	Page 7 of 13
Revision 4	Effective Date 05/18/2018

- Insect Repellent: Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect Repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics.

Notes: The suitability of these items has not been independently verified. Products containing N-diethylmeta-toluamide (DEET), picaridin, and IR3535 and some oil of lemon eucalyptus (OLE) and paramenthane-diol products are known to provide longer-lasting protection than others. One of the products recommended by the Air Force Civil Engineer Center and listed above, Repel Lemon Eucalyptus Insect Repellant, contains OLE and is most likely to be effective.

An independent study (Bartlett and Davis, 2018) of three insect repellents (Sawyer® do-it-yourself permethrin treatment for clothing, Off! Deep Woods® spray for clothing/skin, and Insect Shield® pretreated clothing) determined that these products were free of PFAS compounds (17 compounds were tested for), thus they may be suitable for use on a project-specific basis.

Sample Containers and Shipping Materials:

- Avoid the use of glass or LDPE sample containers, which are believed to result in loss of PFAS through adsorption to the container inner walls.
- Collect samples in clean, laboratory-supplied, plastic bottles only, typically polypropylene for drinking water or HDPE for other matrices.
- Confirm that Teflon-lined caps are not used in sample containers; unlined polypropylene screw caps
 must be used. It is best to segregate sample containers with Teflon components (e.g., Teflon-lined
 septa) from PFAS sample containers.
- Avoid using Blue Ice or similar items to cool samples and avoid placing such items in sample coolers for shipping. Use commercially available (e.g., from convenience stores or supermarkets) doublebagged ice instead.

Caution: Samples designated for PFAS analysis must be cooled to achieve a storage temperature of less than 6 °C. Cooling to this temperature may take several hours, and sample temperatures may not achieve 6 °C by the time they arrive at the laboratory. If sample temperatures upon arrival at the laboratory are not less than 10 °C, the laboratory may conclude that sample preservation was compromised and may reject the samples. Therefore, place samples on ice as soon after collection as possible. On warm days, or when a representative from a nearby laboratory picks up the samples, take extra care (e.g., use more ice or delay shipment, if necessary) to ensure that sample temperatures will not exceed 10 °C when the samples arrive at the laboratory.

• Use of commercially available plastic bags (e.g., 3-mil-thick trash can liners) for lining coolers to prevent leakage and to separate potential melt water from chain-of-custody forms is allowed.

7.2 Other Precautions for Sample Handling

- Wash hands thoroughly before sampling and after handling fast food, carryout food, snacks, or other items that may contain PFAS. Do not carry pre-packaged food items such as candy bars or microwave popcorn into sampling areas.
- Assume that shipping tape used for securing coolers could contain PFAS; therefore, take care not to transfer PFAS from tape to samples.

Number SA-1	.8	Page 8 of 13
Revision 4		Effective Date 05/18/2018

- Minimize exposure of samples to light. This can be done by placing the collected samples into a cooler (with ice) and closing the cooler lid.
- If in doubt about a particular product or item that comes into contact with environmental media to be sampled or is near to sampling operations, consider collecting and analyzing a rinsate blank using laboratory-supplied PFAS-free water to test the item for contamination potential. Consult the Tetra Tech PM in these cases to verify whether collection of additional blanks is warranted.
- Support personnel that are within 3 meters of the sample processing area are considered subject to the same restrictions related to precautionary measures for clothing and food as applied to sampling personnel.

These precautions must be observed during sampling activities, especially during water sample collection (groundwater, water supply, and surface water), given the high solubilities of PFAS in water. Examples of how these precautions may be applied to sampling of specific media are provided in the following sections.

7.3 Groundwater Sample Acquisition

The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for groundwater sampling. Do not proceed any further without reviewing each of those precautions and requirements.

- Collect groundwater samples for PFAS analyses in accordance with this SOP, SOP SA-1.1, and/or project- or client-specific requirements.
- If non-dedicated non-disposable equipment is used between sampling locations, it should be decontaminated with Alconox or Liquinox, unless 1,4-dioxane (a potential component of Liquinox) is also a contaminant of concern. In that case, Liquinox should not be used. Products such as Decon 90, which contains fluorosurfactants, should not be used. Alconox or Liquinox rinses should be followed by a potable water rinse then deionized water rinse. The final decontamination rinse for DoD projects must be with water certified by the laboratory to be PFAS-free.
- If sampling for multiple analytes using PFAS-appropriate equipment, collect samples for PFAS analysis last to ensure adequate purging and conditioning of sampling equipment. If practical to do so, suitable PPE (especially gloves) may also be changed out for PFAS sampling. For example, purge and sample a monitoring well for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals using a peristaltic pump with HDPE and silicone tubing, then collect the material for PFAS analysis. If either the proper sampling sequence or proper equipment is unclear, consult the FOL or Tetra Tech PM and record the actual sequence in the field notes.
- If sampling wells that have or had dedicated Teflon or FEP tubing that potentially contained PFAS, remove the dedicated tubing and, using silicone or HDPE tubing, remove at least one well volume from the target sampling interval prior to sampling. Accomplish this removal in a manner that is rigorous enough to remove the entire water column from the well and not just a limited vertical interval of the water column. This will minimize the potential for collecting a sample that was in contact with the Teflon/FEP tubing.
- The use of detergents must be avoided during decontamination of drilling or other heavy equipment. All equipment must be scrubbed with a plastic brush or steam cleaned with potable water, and rinsed thoroughly in potable water to clean away any debris or material on exposed surfaces.

Subject	
SAMPLE ACQUISITION FOR	
PERFLUOROALKYL AND	
POLYFLUOROALKYL SUBSTANCES	5
(PFAS) ANALYSIS	

Number SA-1.8	Page 9 of 13
Revision 4	Effective Date 05/18/2018

- Sample(s) representing any water collected at the point of use (e.g., water truck or tank on site) used by the driller for drilling purposes must be analyzed for PFAS. See Section 7.8 for guidance on waste management.
- Collect drinking water samples to be analyzed using U.S. EPA Method 537 in clean polypropylene sample bottles with a polypropylene screw cap; for all other samples, use clean, laboratory-supplied, HDPE bottles with unlined plastic screw caps.

7.4 <u>Soil Sample Acquisition</u>

The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for soil sampling. Do not proceed any further without reviewing each of those precautions and requirements.

- Collect soil samples for PFAS analyses in accordance with this SOP, SOP SA-1.3, and/or project- or client-specific requirements. Review client-specific (e.g., DoD component) guidance or previously approved Sampling and Analysis Plans (SAPs).
- Soil sampling equipment should not be constructed of or contain Teflon or other materials likely to contain or be coated with PFAS. Acceptable materials for sampling include stainless steel, acetate, and HDPE.
- If non-dedicated non-disposable equipment is used between sampling locations, it should be decontaminated with Alconox or Liquinox, unless 1,4-dioxane (a potential component of Liquinox) is also a contaminant of concern. In that case, Liquinox should not be used. Products such as Decon 90, which contains fluorosurfactants, should not be used. Alconox or Liquinox rinses should be followed by a potable water rinse then deionized water rinse. The final decontamination rinse for DoD projects must be with water certified by the laboratory to be PFAS-free.
- Collect samples in laboratory-provided HDPE containers specifically designated for PFAS analysis.
 Do not use glass jars typically used for soil sample collection because some PFAS may irreversibly adsorb to the glass and could create a negative bias in the measured PFAS concentrations.

7.5 Surface Water and Sediment Sample Acquisition

The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for surface water and sediment sampling. Do not proceed any further without reviewing each of those precautions and requirements.

- Collect surface water and sediment samples for PFAS analysis in accordance with this SOP, SOP SA-1.2, and/or project- or client-specific requirements.
- Surface water and sediment sampling equipment should not be constructed of or contain Teflon or LDPE materials. Acceptable materials for sampling include HDPE, silicone, stainless steel, and acetate. Do not use glass. The bottleware should be supplied clean by the laboratory and specifically designated for PFAS analysis. If transfer bottles are required for collection of surface water samples, the transfer bottles used should be of the same material as the containers designated for submission to the laboratory.
- For surface water sample collection, invert the capped sample bottle, with the opening pointing downward, at least 10 cm below the water surface, at least 10 cm above the bottom of the water body, and as close to the center of the channel or water body as practical. To collect the sample,

Number SA-1.8	Page 10 of 13
Revision 4	Effective Date 05/18/2018

uncap the bottle underneath the water surface and point the bottle upward so that gloved hands, sample container, and sampler are downstream of where the sample is being collected.

- For aquatic samples collected from the shoreline or via wading, ensure that waders are constructed of fabric that has not been treated with waterproofing coatings, and stand downstream of the sample bottle during sample collection.
- If non-dedicated non-disposable sampling equipment is used between sampling locations, it should be decontaminated with Alconox or Liquinox, unless 1,4-dioxane (a potential component of Liquinox) is also a contaminant of concern. In that case, Liquinox should not be used. Products such as Decon 90, which contains fluorosurfactants, also should not be used. Alconox or Liquinox rinses should be followed by a potable water rinse then deionized water rinse. The final decontamination rinse for DoD projects must be with water certified by the laboratory to be PFAS-free.
- Avoid reusing non-stainless-steel equipment (e.g., porewater observation devices consisting of slotted PVC pipe and silicone tubing) when collecting porewater samples.

7.6 Water Supply Sampling

This section applies to sampling from taps, spigots, faucets, or similar devices for PFAS analysis. The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for water supply sampling. Do not proceed any further without reviewing each of those precautions and requirements.

- Collect water supply samples for PFAS analysis in accordance with applicable portions of SOP SA-1.7 and/or project- or client-specific requirements.
- Water supply sampling equipment (if needed) should not be constructed of or contain Teflon or LDPE materials. Acceptable materials for sampling include HDPE, polypropylene (drinking water sampling only), small amounts of silicone (e.g., short runs of silicone tubing used in peristaltic pumps), stainless steel, and acetate. Non-drinking water supply samples should be collected in clean, laboratory-supplied, HDPE bottleware specifically designated for PFAS analysis (not glass). Collect drinking water samples in clean polypropylene bottles supplied by the laboratory.
- Ensure that sample bottles used to collect chlorinated water samples contain the proper Trizma preservative (5 g/L to remove chlorine). Non-chlorinated water does not require chemical preservatives designed to remove chlorine.
- If non-dedicated non-disposable equipment is used between sample locations, it should be decontaminated with Alconox or Liquinox unless 1,4-dioxane (a potential component of Liquinox) is also a contaminant of concern. In that case, Liquinox should not be used. Products such as Decon 90, which contains fluorosurfactants, also should not be used. Alconox or Liquinox rinses should be followed by a potable water rinse then deionized water rinse. The final decontamination rinse for DoD projects must be with water certified by the laboratory to be PFAS-free.
- Locate the sampling point. If a specific sampling point has already been designated (e.g., a kitchen tap), plan to collect the sample from that point. Otherwise, identify a location in the water supply line that is as close as possible to the water's point of origination (e.g., a well or other water source) and upstream of any local water treatment unit(s) that could affect PFAS levels (e.g., water softeners, activated carbon, or reverse osmosis treatment units). If a treatment unit is in use, a post-treatment sample may also be required in some cases, per project requirements.

Number SA-1.8	Page 11 of 13
Revision 4	Effective Date 05/18/2018

Note: If treatment that could affect PFAS levels (e.g., carbon filtration or reverse osmosis) is part of the water distribution system, often a spigot will be present in the plumbing line between the water source and the treatment unit, and this spigot should be used for sample collection.

- Remove any aerator/diffuser from the faucet, if possible. If removal is not possible, record this
 observation in the field notes.
- Allow the water to run freely from the tap until water quality parameter stabilization per project-specific requirements is achieved, or as otherwise required by project-specific requirements. This will often require purging for 3 to 5 minutes.
- Reduce the water flow rate to minimize aeration of the sample. The water stream should be no wider than the diameter of a pencil.
- Fill the sample bottle (typically 250 mL) directly from the tap to the bottom of the neck of the bottle, and cap the bottle immediately.
- After collecting the sample, cap the bottle and, if preservative is included, agitate by hand until the preservative is dissolved.
- Do not use filters when collecting samples because the filters may introduce PFAS contamination or absorb PFAS and thus reduce PFAS concentrations in the samples.

7.7 Field Reagent Blank Collection

Note: If PFAS are detected in site samples, FRBs may be analyzed to assess whether PFAS in site samples could be non-site-related contamination and whether resampling is necessary. U.S. EPA Method 537 and modifications or derivatives thereof for PFAS analysis require an FRB to be handled along with each sample set. A sample set is described as samples collected from the same sample site and at the same time, but "sample site" and "same time" are not precisely defined. Therefore, it is important to verify that the correct number of FRBs will be collected. The intent is to be able to verify whether samples have been contaminated and to help identify the source of contamination. In general, collecting one FRB at each sampling point is recommended when sampling drinking water; fewer FRBs are recommended when sampling non-drinking water matrices. The actual number will depend on project needs. *Collection of an FRB at every sampling point may be required.*

Verify the number of FRBs to be collected for the project and where those samples must be collected.
 This should be described in the project planning documents such as work plans or SAPs. If it is not, consult the PM.

Note: Chemical preservative may not be included in FRBs that are used when sampling non-drinking water matrices.

- At the sampling site, when ready to collect an FRB, open the bottle of chemically preserved FRB
 reagent water provided by the laboratory and a corresponding clean empty bottle, also provided by
 the laboratory.
- Pour the preserved FRB reagent water into the empty sample bottle, close the cap, and label this filled bottle as the FRB.

Subject
SAMPLE ACQUISITION FOR
PERFLUOROALKYL AND
POLYFLUOROALKYL SUBSTANCES
(PFAS) ANALYSIS

Number SA-1.8	Page 12 of 13
Revision 4	Effective Date 05/18/2018

 Pack and ship the FRB along with site samples and required documentation (e.g., chain-of-custody form) to the laboratory.

Note: Although chain-of-custody forms will indicate that FRBs must be analyzed for PFAS, analysis of an FRB will be required only if site samples contain PFAS greater than a certain concentration. If an FRB is analyzed and any PFAS concentration in the FRB exceeds one-third of the laboratory minimum reporting limit (or equivalent), all samples collected with that FRB may be considered invalid and may require recollection and reanalysis. Consult the project planning documents governing sample collection for specifics as to whether resampling is necessary. Care in collection and handling of site samples and FRBs in a way that avoids contamination cannot be overemphasized.

Note: It will be necessary to associate individual FRBs with corresponding site samples; otherwise, decisions about which samples to recollect (if recollection is indicated) could be compromised. Associations between FRBs and corresponding site samples may be accomplished by marking chain-of-custody forms with the associations, but other methods also may be useful. Consult the governing planning document or the PM for guidance, if necessary.

7.8 Disposal of Investigation-Derived Waste Potentially Containing PFAS

PFAS are not hazardous wastes as defined in the Resource Conservation and Recovery Act and Comprehensive Environmental Response, Compensation, and Liability Act. It may be possible to dispose of PFAS-containing solid waste as non-hazardous, but sampling solid waste material for PFAS analysis is not advised. Consult the client PM or on-site point of contact to verify their current disposal acceptance criteria, and indicate on waste manifests that the waste potentially contains PFAS. Waste water potentially containing PFAS should be analyzed for PFAS to determine the appropriate disposal option. If the sum of PFOA and PFOS concentrations is less than 70 ng/L the water may be disposed of without special handling if no other enforceable regulations apply; otherwise, the water should be treated to reduce the PFOA + PFOS concentration to an acceptable level or should be directed to an appropriate treatment facility for disposal. On-site treatment (e.g., granular activated carbon filtration) may be appropriate. Consult the client PM or on-site point of contact for direction regarding disposal.

Note: If aqueous investigation-derived waste (IDW) is expected to contain greater than 70 ng/L combined PFOA and PFOS (e.g., captured residual AFFF or AFFF concentrate from an accidental release in a hangar), special actions may be necessary and the client PM should be consulted. For wastes that are dewatered and potentially contain PFAS, containerize the waste water and analyze it for PFAS prior to disposal.

8.0 REFERENCES

ATSDR, (Agency for Toxic Substances and Disease Registry), Division of Toxicology and Environmental Medicine, 2009. Toxicological profile for perfluoroalkyls. U.S. Government Printing Office. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=1117&tid=237.

ASTSWMO (Association of State and Territorial Solid Waste Management Officials, Remediation and Reuse Focus Group), Federal Facilities Research Center, 2015. Perfluorinated Chemicals (PFCs): Perfluoroctanoic Acid (PFOA) and Perfluoroctane Sulfonate (PFOS), Information Paper. August

Bartlett and Davis, 2018. Evaluating PFAS cross contamination issues. Remediation, 2018;28:53-57.

DoD (Department of Defense), 2011. Chemical & Material Emerging Risk Alert Aqueous Film Forming Foam (AFFF). Risk Alert # 03-11. Materials of Evolving Regulatory Interest Team.

Subject
SAMPLE ACQUISITION FOR
PERFLUOROALKYL AND
POLYFLUOROALKYL SUBSTANCES
(PFAS) ANALYSIS

Number SA-1.8	Page 13 of 13
Revision 4	Effective Date 05/18/2018

Department of the Navy, 2014. Perfluorinated Compounds (PFCs) Interim Guidance/Frequently Asked Questions (FAQs). December.

Chemical & Material Emerging Risk Alert Aqueous Film Forming Foam (AFFF). Risk Alert # 03-11. Materials of Evolving Regulatory Interest Team.

NAVFAC, 2017. Interim Per-and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update.

New Hampshire Department of Health and Human Services, 2014. Fact Sheet, Perfluorinated Chemicals (PFCs). May.

- U.S. EPA (United States Environmental Protection Agency), 2009. Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), Version 1.1, EPA/600/R-08/092. September.
- U.S. EPA (United States Environmental Protection Agency), 2014. Emerging Contaminants Perflurooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). Emerging Contaminants Fact Sheet PFOS and PFOA. EPA-50-F-14-001. March.
- U.S. EPA, 2015. Perfluorooctanoic Acid (PFOA) and Fluorinated Telomers Frequent Questions. http://www.epa.gov/oppt/pfoa/pubs/faq.html. Accessed April 27.



STANDARD OPERATING PROCEDURE

N	umber SA-6.3	Page 1 of 14
Ef	ffective Date 9/28/2017	Revision 6

Applicability

Tetra Tech, Inc., NUS Operating Unit

Prepared

Earth Sciences Department

Subject

FIELD DOCUMENTATION

Approved T. Johnston

tom. johnston @tetratec Digitally signed by: tom. johnston@tetratech.com DN: CN = tom. johnston@tetratech.com Date: 2017.09.28 13:35:13 -

TABLE OF CONTENTS

SECT	<u>ION</u>		<u>PAGE</u>
1.0	PURPO	DSE	2
2.0	SCOPE	E AND APPLICABILITY	2
3.0	GLOSS	SARY	2
4.0	RESPO	DNSIBILITIES AND PERSONNEL QUALIFICATIONS	2
5.0	PROCE	EDURES	3
	5.1 5.1.1 5.1.2 5.2 5.3 5.3.1 5.3.2 5.3.3 5.4 5.4.1 5.4.2	SITE LOGBOOK General Photographs and Other Images FIELD NOTEBOOKS FIELD FORMS Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Hydrogeological and Geotechnical Forms Equipment Calibration and Maintenance Form FIELD REPORTS Daily Activities Report Weekly Status Reports	
6.0	LISTIN	G OF FIELD FORMS ON THE NUS OPERATING UNIT INTRANET SITE	9
7.0		RENCES	10
<u>ATTA</u>	CHMENT	' <u>S</u>	
(A B C D	TYPICAL SITE LOGBOOK ENTRYSAMPLE LABEL (EXAMPLE)CHAIN-OF-CUSTODY FORM (EXAMPLE)CHAIN-OF-CUSTODY SEAL (EXAMPLE)	12 13

Subject	Number SA-6.3	Page 2 of 14
FIELD DOCUMENTATION	Revision	Effective Date
	6	9/28/2017

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting NUS Operating Unit field activities.

2.0 SCOPE AND APPLICABILITY

Documents presented within this SOP (and related sampling SOPs) shall be used for all NUS Operating Unit field activities, as applicable. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling and documentation effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Project Manager (PM)</u> - The PM is responsible for obtaining hardbound controlled-distribution logbooks (from the appropriate source), as needed. In addition, the PM is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

<u>Field Operations Leader (FOL)</u> - The FOL is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports included in this SOP (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time frame.

<u>Site Safety Officer (SSO)</u> - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP) (or equivalent).

<u>Project Geologist/Sampler</u> - The Project Geologist/Sampler is responsible for the proper documentation of field activities in accordance with this SOP and/or other project-specific documents.

General personnel qualifications for field documentation activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for documentation, handling, packaging, and shipping.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 3 of 14
	Revision 6	Effective Date 9/28/2017

5.0 PROCEDURES

5.1 <u>SITE LOGBOOK</u>

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, record or reference the following activities/events (daily) in the site logbook:

- All field personnel present
- Arrival/departure times and names of site visitors
- Times and dates of health and safety training
- Arrival/departure times of equipment
- Times and dates of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation activities, etc.
- Daily on-site activities
- Sample pickup information
- Health and safety issues (level of protection, personal protective equipment [PPE], etc.)
- Weather conditions

Maintain a site logbook for each project and initiate it at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Make entries every day that on-site activities take place involving NUS Operating Unit or subcontractor personnel. Upon completion of the fieldwork, provide the site logbook to the PM (or qualified designee) for inclusion in the project's central file.

Record the following information on the cover of each site logbook:

- Project name
- NUS Operating Unit project number
- Seguential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, either record the measurements and equipment used in the site logbook or reference the field notebook in which the measurements are recorded (see Attachment A).

Make all logbook, notebook, and log sheet entries in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, cross out the entry with a single strike mark, initial, and date it. At the completion of entries by any individual, the logbook pages used must be signed and dated by the person making the entries. The site logbook must also be signed by the FOL at the end of each day.

5.1.2 Photographs and Other Images

Permission to take photographs, make movies, or otherwise record visual representations of site features, activities, or facility personnel on certain properties such as military installations is a temporary privilege bestowed upon a person (i.e., the photographer) by the property owner and the particular facility at which the photographs are taken. In the case of U.S. military installations, the U.S. Government and Installation Command bestow this privilege. For the remainder of this section the term "image" is intended to represent

Subject	Number SA-6.3	Page 4 of 14
FIELD DOCUMENTATION	Revision 6	Effective Date 9/28/2017

all visual forms of documentation of site features, activities, or personnel, such as film and digital still images and movies.

It may be illegal to record images without proper authorization and the photographer may be criminally liable for their actions. This is especially true on or near U.S. Government property. A particular image alone may not constitute an act of espionage or a national security threat; however, nefarious persons and organizations could conceivably combine information from multiple sources to create a national security threat. Therefore, the photographer must comply with any and all restrictions imposed on them by authorized facility personnel.

The instructions below apply to formal and casual photography sessions conducted, for example, during on-site meetings, walkovers, and other visits. Persons recording images should be aware that images recorded on or near military installations, and possibly at other installations, may be subject to censorship and clearance, e.g., through Public Affairs or Public Relations Offices.

CAUTION

Fieldwork-specific SOPs establish safety precautions for the fieldwork that they govern. When recording images, adhere to all safety precautions associated with fieldwork described in those SOPs. Pay attention to your surroundings. Avoid unsafe locations and positions. Avoid walking or turning your body while looking through the lens or viewfinder of a camera unless the path of movement has been cleared in advance and the movements will be made safely. Be especially alert to trip and fall hazards. Dress appropriately for the weather, topography, and the flora and fauna. Stay hydrated, and be aware of the effects of heat and cold stress on the body. Consult the SSO if in doubt about your safety or the safety of others while recording images.

5.1.2.1 <u>Prior to and during photography sessions, follow these steps:</u>

Note: In general, avoidance of specialty photographic equipment reduces the amount of work required of the photographer. The photographer is not required to record aperture, shutter speed, ISO rating, or other camera settings within automatic exposure ranges available on digital cameras; however use of special lenses (e.g., tilt-and-shift), filters (e.g., neutral density, warming, and polarizing filters), and other image enhancement equipment or techniques must be noted in the logbook/notebook. If possible, use of such equipment items or special techniques should be avoided because they can adversely affect the accuracy of recorded images.

- By communicating with the facility point of contact prior to recording images, obtain permission directly
 from, or on behalf of, the property owner and/or operator to record the images. In the case of U.S.
 Government military installations, the point of contact typically represents the Installation Command or
 a higher authority. The actual point of contact is frequently a Public Works or Environmental
 Department staff member.
- Request from the facility point of contact a written pass that allows permission to record images (hereafter referred to as a photography pass) but do not insist on obtaining one if the facility declines to issue such a pass.
- If the facility does not issue a written photography pass, either do not record images or verify via written
 communication with the facility point of contact that image making will be permitted while on the
 Installation property.

Note: The intent of these permissions and communications is to ensure that the photographer clearly communicates his or her intentions to the facility and to avoid disputes regarding appropriateness of images, ownership of images or property depicted in the images, violation of privacy, etc. During

Subject	Number	Page
FIELD DOCUMENTATION	SA-6.3	5 of 14
	Revision	Effective Date
	6	9/28/2017

communication with the facility point of contact, ensure that they understand the types of scenes, activities, equipment, features, processes, etc., to be recorded visually and under what conditions the images will be made.

- If the facility issues a written photography pass:
 - Prior to recording images, verify that the photography pass is valid for the time period during which images will be made.
 - o Carry the written photography pass in your possession when recording images.
 - Be prepared to produce the photography pass as proof of permission to record images.
- Prior to recording images, if using a digital recording medium, enable automatic collection of Exchangeable Image File (EXIF) data. Doing so will provide automatic documentation of the camera settings (ISO rating, shutter speed, aperture, focal length, etc.) used during image capture. Most digital cameras will record this information by default; but the use of special filters or other attachments to the image capture device is not recorded because such equipment is not an integral part of the device.
- While recording images, enter the name of the photographer, date, time, site location, and site
 description in the logbook/notebook and update this information as necessary to document important
 changes. Include other pertinent information such as weather conditions, if such information will
 support interpretation of the images.
- When orientation of the camera is important to interpreting the contents of the images, record the
 camera angles and positions for each image. This may be done by drawing an arrow on a site figure
 that points in the same direction the camera was pointed when the image was recorded. Alternatively,
 some digital cameras may automatically record the geographical coordinates and orientation angle
 during image capture.
- Sequentially number images of a site or monitoring location to correspond to logbook/notebook entries.
 Digital still image media typically provide automatic numbering of images. If desired, the image numbers may be altered later (e.g., during download to a computer) but it may be desirable to retain the original file name in the EXIF data for traceability.

5.1.2.2 After recording images follow these steps:

- Verify that the name of the photographer, date, time, site location, site description, and other pertinent notes were correctly entered in the logbook/notebook.
- Compile the images and associated information that will be necessary to interpret them in a manner suitable for the associated project. For example, consecutively number still images and label them according to the logbook/notebook descriptions. If camera angle, camera position, or camera settings are important, record this important information with the images. For moving images, edit and compile the images a manner consistent with the intended use.
- Docket the images and associated film negatives or digital files to the central project file and/or compact
 disk. If EXIF data were captured and are needed for the project, ensure the EXIF data are transferred
 along with the image to the final storage location. This final storage location may be a project file or a
 report compiled to document site conditions.
- If multiple versions of image files are generated (e.g., high resolution and low resolution), arrange for proper storage and management of all versions of files for ready retrieval and safe storage.

Subject	Number SA-6.3	Page 6 of 14
FIELD DOCUMENTATION	Revision 6	Effective Date 9/28/2017

5.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the SSO may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each Project Geologist/Sampler assigned to oversee a rig must maintain a field notebook.

5.3 FIELD FORMS

Field forms (see list in Section 6.0 of this SOP) can be found on the NUS Operating Unit intranet site under "Field Log Sheets." Forms may be altered or revised for project-specific needs, subject to client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOPs.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 <u>Sample Log Sheet</u>

Sample log sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. Complete a sample log sheet for each sample obtained, including field quality assurance (QA) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Complete the required information on the adhesive labels and apply them to every sample container. Obtain sample labels from the appropriate program/project source, request that they be electronically generated in house, or request them from the laboratory subcontractor.

CAUTION

Some labels (e.g., paper labels) may become soaked with water from melted ice or condensation during shipping. This soaking could render the labels illegible or cause them to fall off of their containers. Therefore, all paper labels and other labels subject to such deterioration should be covered with clear protective tape (e.g., packing tape) to keep them dry during shipment. Avoid wrinkles in the tape that could directly interfere with legibility of the label or allow contact with water. Covering all hand-written sample container labels (paper or otherwise) with protective tape in this manner is an absolute requirement when collecting samples in support of United States Environmental Protection Agency (USEPA) Contract Laboratory Program (CLP) projects.

5.3.1.3 Chain-of-Custody Record

The chain-of-custody record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used as follows for any samples collected for chemical or geotechnical analysis whether the analyses are performed on-site or off-site:

- Retain one carbonless copy of the completed chain-of-custody form in the field.
- Send one copy to the PM (or qualified designee).
- Send the original (top, signed copy) to the laboratory with the associated samples. Place the original chain-of-custody copy inside a large Ziploc®-type bag taped inside the lid of the shipping cooler. If

Subject	Number	Page
FIELD DOCUMENTATION	SA-6.3	7 of 14
	Revision 6	Effective Date 9/28/2017

multiple coolers are sent, but are included on one chain-of-custody form, send the form with the cooler containing vials for volatile organic compounds (VOCs) analysis or the cooler with the air bill attached. Indicate on the air bill how many coolers are included with that shipment.

An example of a chain-of-custody form is provided as Attachment C. After the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed chain-of-custody form (any discrepancies between the sample labels and chain-of-custody form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the PM or qualified designee). The chain-of-custody form is signed and copied. The laboratory will retain the copy, and the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label that is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. Sign and date custody seals and affix them across the lid and body of each cooler (front and back of opposite sides) containing environmental samples (see SOP SA-6.1). Obtain custody seals from the laboratory (if available) or purchase them from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Complete Field Analytical Log Sheets to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 <u>Groundwater Level Measurement Sheet</u>

Complete a Groundwater Level Measurement Sheet for each round of water level measurements made at a site.

5.3.2.2 <u>Data Sheet for Pumping Test</u>

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. Use a Pumping Test Data Sheet to facilitate this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be established in advance.

5.3.2.3 Packer Test Report Form

Complete a Packer Test Report Form for each well at which a packer test is conducted.

5.3.2.4 Boring Log

Complete a Summary Log of Boring, or Boring Log for each soil boring performed to document the materials encountered, operation and driving of casing, and locations/depths of samples collected. In addition, if volatile organic vapors are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a photoionization detector [PID] or flame ionization detector [FID]), enter these readings on the boring log at the appropriate depth. When they become available, enter the laboratory sample number, concentrations of key contaminants, or other pertinent information in the "Remarks" column. This feature allows direct comparison of contaminant concentrations with soil characteristics.

Subject	Number SA-6.3	Page 8 of 14
FIELD DOCUMENTATION	Revision 6	Effective Date 9/28/2017

5.3.2.5 <u>Monitoring Well Construction Details Form</u>

Complete a Monitoring Well Construction Details Form for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 <u>Test Pit Log</u>

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible Project Geologist/Sampler.

5.3.2.7 <u>Miscellaneous Monitoring Well Forms</u>

Miscellaneous monitoring well forms that may be required on a project-specific basis include the Monitoring Well Materials Certificate of Conformance and Monitoring Well Development Record. Use a Monitoring Well Materials Certificate of Conformance to document all materials utilized during each monitoring well installation. Use a Monitoring Well Development Record to document all well development activities.

5.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Miscellaneous field forms/checklists that may be required on a project-specific basis include the following:

- Container Sample and Inspection Sheet use this form when a container (drum, tank, etc.) is sampled and/or inspected.
- QA Sample Log Sheet use this form when a QA sample such as an equipment rinsate blank, source blank, etc. is collected.
- Field Task Modification Request (FTMR) use this form to document deviations from the project planning document(s). The FOL is responsible for initiating the FTMRs. Maintain copies of all FTMRs with the on-site planning documents, and place originals in the final evidence file.
- Field Project Daily Activities Checklist and Field Project Pre-Mobilization Checklist use these during both the planning and field effort to ensure that all necessary tasks are planned for and completed. These two forms are not requirements, but are useful tools for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure the proper operation and response of the equipment, to document the accuracy, precision, or sensitivity of the measurements, and to determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log, which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. Maintain an Equipment Calibration Log for each electronic measuring device used in the field; make entries for each day the equipment is used or in accordance with manufacturer recommendations.

Subject	Number SA-6.3	Page 9 of 14
FIELD DOCUMENTATION	Revision 6	Effective Date 9/28/2017

5.4 FIELD REPORTS

The primary means of recording on-site activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation but are not easily used for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain on site for extended periods of time and are thus not accessible for timely review by project management. Other reports useful for tracking and reporting the progress of field activities are described below.

5.4.1 Daily Activities Report

To provide timely oversight of on-site contractors, complete and submit Daily Activities Reports (DARs) as described below.

5.4.1.1 Description

The DAR documents the activities and progress for each day's field work. Complete this report on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring that involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the NUS Operating Unit intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the DAR to the FOL for review and filing. The DAR is not a formal report and thus requires no further approval. The DARs are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the PM.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

In addition to those described herein, other summary reports may also be contractually required. Field forms can be found on the NUS Operating Unit intranet site.

6.0 LISTING OF FIELD FORMS ON THE NUS OPERATING UNIT INTRANET SITE

- Boring Log
- Container Sample and Inspection Sheet
- Daily Activities Checklist
- Daily Activities Record
- Equipment Calibration Log
- Field Task Modification Request Form
- Field Analytical Log Sheet Geochemical Parameters
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Hydraulic Conductivity Testing Data Sheet
- Low Flow Purge Data Sheet

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 10 of 14
	Revision 6	Effective Date 9/28/2017

- Bedrock Monitoring Well Construction (Stick Up)
- Bedrock Monitoring Well Construction (Flush Mount)
- Bedrock Monitoring Well Construction (Open Hole)
- Confining Layer Monitoring Well Construction
- Monitoring Well Development Record
- Monitoring Well Materials Certificate of Conformance
- Overburden Monitoring Well Construction (Flush Mount)
- Overburden Monitoring Well Construction (Stick Up)
- Packer Test Report Form
- Pumping Test Data Sheet
- QA Sample Log Sheet
- Soil & Sediment Sample Log Sheet
- Surface Water Sample Log Sheet
- Test Pit Log
- Field Project Pre-Mobilization Checklist

7.0 REFERENCES

USEPA, 2016. Sampler's Guide, Contract Laboratory Program Guidance for Filed Samplers, Office of Superfund Remediation and Technology Transfer, OSWER 9200.2-147, EPA-540-R-014-013, October.

Subject	Number SA-6.3	Page 11 of 14
FIELD DOCUMENTATION	Revision 6	Effective Date 9/28/2017

ATTACHMENT A

	TYPICAL SITE LOGBOOK ENTRY
START T	ΓΙΜΕ: DATE:
SITE LEA	ADER:
PERSON	
WEATHE	ER: Clear, 68°F, 2-5 mph wind from SE
ACTIVITI	IES:
1.	Steam jenney and fire hoses were set up.
2.	Drilling activities at well resumes. Rig geologist was See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well
3.	Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well
4.	Well drilled. Rig geologist was See Geologist's Notebook, No. 2, page for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5.	Well was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6.	EPA remedial project manager arrives on site at 14:25 hours.
7.	Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit
8.	Test pit dug with cuttings placed in dump truck. Rig geologist was See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit resulted in a very soft and wet area. A mound was developed and the area roped off.
9.	Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.
	Field Operations Leader

Subject	Number SA-6.3	Page 12 of 14
FIELD DOCUMENTATION	Revision 6	Effective Date 9/28/2017

ATTACHMENT B SAMPLE LABEL (EXAMPLE)

TŁ	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:	
Sample N	lo:		Matrix:
Date:	Time:	Preserve	:
Analysis			
Sampled	by:	Laborato	ry:

PROJECT SAMPLER	RS (SIGNATURE)	FACILITY:		FIELD	OPER	ANAGER	LEADEF NUMBER	Pi	UMBER HONE N	UMBER		A	ABORA DDRES	ss		OF _				FIELD DOCUMENTATION	
RUSH TAT	RD TAT	hr.	14 day	DEPTH (FT)	ВОТТОМ БЕРТН (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS	PLAS PRES USED	SERVAT	or GLAS	3S (G)		7				CHAIN-OF		A	1
TEAR TO	IME S	AMPLE ID	7007	4OT	ПОВ	MATE ETC.)	COLL	No. O								_ α	CMANES VITS	CHAIN-OF-CUSTODY FORM (EXAMPLE)	ATTACHMENT C	Revision 6	SA-6.3
2. RELING	DUISHED BY DUISHED BY DUISHED BY			DATE DATE			TIME TIME	2. R	RECEIVE	D BY					DA DA	TE	TIME TIME TIME			Effective Date 9/28/2017	13 of 14

Subject	Number SA-6.3	Page 14 of 14
FIELD DOCUMENTATION	Revision 6	Effective Date 9/28/2017

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL (EXAMPLE)

Slgnature	CUSTODY SEAL
Date	Date
CUSTODY SEAL	Signature



STANDARD OPERATING PROCEDURE

Number	Page
SA-7.1	1 of 17
Effective Date	Revision
7/15/2016	8

Applicability

Tetra Tech, Inc., NUS Operating Unit

Prepared

Earth Sciences Department

Subject

DECONTAMINATION OF FIELD EQUIPMENT AND MANAGEMENT OF INVESTIGATION DERIVED **WASTE**

Approved T. Johnston

johnston

johnston

@tetratec

b. com

Digitally signed by: tom.
johnston@tetratech.com
DN: CN = tom.
johnston@tetratech.com
Date: 2016.07.14 10:21:
43 -05'00'

h.com

TABLE OF CONTENTS

SECT	ΓΙΟΝ	<u>PAGE</u>
1.0	PURPO	SE2
2.0	SCOPE	AND APPLICABILITY2
3.0	GLOSS	ARY2
4.0	RESPO	NSIBILITIES AND PERSONNEL QUALIFICATIONS3
5.0		H AND SAFETY4
6.0		MENT LIST4
7.0		DURES
	7.1 7.1.1 7.1.2 7.1.3 7.2 7.2.1 7.2.2 7.2.3 7.3 7.4	Decontamination Pad Design/Construction Considerations6Temporary Decontamination Pads6Decontamination Activities at Drill Rigs/DPT Units8Decontamination Activities at Remote Sample Locations8Equipment Decontamination Procedures8Monitoring Well Sampling Equipment8Downhole Drilling Equipment10Soil/Sediment Sampling Equipment12Contact Waste/Materials13Decontamination Evaluation14
ATTA	CHMENT	<u>S</u>
A B		GATION-DERIVED WASTE LABEL

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 2 of 17
	Revision 8	Effective Date 07/15/2016

1.0 PURPOSE

Decontamination is the process of removing, or neutralizing contaminants that have contacted and/or accumulated on equipment and/or personnel. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination to prevent either direct or indirect contamination of drilling equipment, earth-moving equipment, chemical sampling equipment, and analytical equipment. It is also intended through the application of these principles to prevent cross-contamination of the environment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Chemical/Hygienic/Sanitizing wipes – These types of devices offer a portable solution when there are no sources of water and soap to allow hands, face, or equipment to be cleaned of gross contamination. Some of these wipes and solution based detergents are chemical specific such as D-Lead or D-Wipes are used to remove lead and other heavy metals from hands and face.

<u>Decontamination Solution</u> - A solution selected/identified in the Health and Safety Plan (HASP), Project-Specific Quality Assurance Project Plan (QAPP), or other governing document. The solution is selected and employed as directed by the project chemist/health and safety professional as it has been shown to be most effective in the removal, neutralization, and/or stabilization of the contaminants in question without creating unwanted byproducts.

<u>Deionized Water (DI)</u> – This is water that has been treated by passing it through a deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Dry decontamination – This method physically removes contaminates from the surface through the use of High Efficiency Particulate Filter vacuums employed for lead and asbestos operations.

<u>Potable Water</u> - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

<u>Pressure Washing</u> - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from the surface of equipment. This process can be coupled with wash solutions or used solely as a pressure washer to physically remove surface artifacts.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 3 of 17
	Revision 8	Effective Date 07/15/2016

<u>Solvent</u> – A solvent is a liquid that is able to dissolve other substances, or solutes, (gases, liquids and/or solids) to form a solution. A solution is a homogeneous mixture of solvent and solute. Water is often referred to as a universal solvent because of its ability to dissolve many different types of substances. The category "solvent" includes but is not limited to pesticide-grade isopropanol; methanol; acetone; and hexane. These solvents may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, polychlorinated biphenyls (PCBs), or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on polyvinyl chloride (PVC) equipment or well construction materials. Acidic and caustic materials may also serve as solutes and when mixed with water may be used for the purpose of decontamination.

<u>Steam Pressure Washing</u> - A cleaning method employing a high-pressure spray of heated potable water (steam) to remove various organic/inorganic chemicals from equipment. This method is useful for removing organic substances such as pesticides, PCBs, oils, and fuels.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Project Manager (PM)</u> - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

<u>Decontamination Personnel</u> - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process, including:

- A working knowledge of the use of all equipment involved (pressure washers, steam cleaners, etc.).
- Hazards associated with the solutions used for this purpose.
- The monitoring of the decontamination process to ensure that it is working properly. This is accomplished through:
 - Visual evaluation (i.e., answering the question: "Does it appear to be clean?"),
 - Employing monitoring instruments and scanning of decontaminated items do determine if offgassing indicates the presence of contaminants , and/or
 - Through the collection of equipment rinsate blanks to verify contaminant removal.
 - Focusing on tools that contact sampled media as well as areas on those tools that trap dirt and contaminated water.
 - Diligent use of PPE and self-decontamination to minimize the potential for cross contamination.
- Replace wash waters often to minimize the collection of contaminants.

<u>Field Operations Leader (FOL)</u> - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation as well as assigning or evaluating the decontamination process. Additionally, through concurrence with the PM, the FOL may:

• Initiate site investigation/remediation efforts in the area where the least amount of contamination is reported thereby minimizing the potential for cross contamination.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 4 of 17
	Revision 8	Effective Date 07/15/2016

• Use disposable devices to collect sample aliquots to minimize cross contamination that might otherwise occur through the use of reusable items.

<u>Site Safety and Health Officer (SSHO)</u> - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination process and evaluation. This is accomplished through visual examination and/or instrument screening, where contaminants can be detected to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour General Site Worker and/or applicable
 8-Hour General Site Worker Refresher training.
- Capability of performing field work under the expected physical (heavy lifting and moving auger flights and drill rods) and environmental (i.e., weather heat and/or cold extremes) conditions.
- Familiarity with appropriate decontamination procedures. Throughout this SOP, the procedures remove
 gross contamination from top down, outside in, then moving to what may be described as "polishing
 stages" where solvents including laboratory grade isopropanol and deionized water are used to remove
 residual levels of contaminants.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Safety Data Sheet (SDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific HASP (or equivalent) for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).
- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Plastic sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project HASP (or equivalent).
- Soap and water for physical washing and rinsing.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 5 of 17
	Revision 8	Effective Date 07/15/2016

- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting equipment rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated
 equipment for organic vapors generated through the existence of residual contamination or the
 presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants or neutralization of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities
- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 6 of 17
	Revision 8	Effective Date 07/15/2016

7.1 <u>Decontamination Pad Design/Construction Considerations</u>

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be and are generally employed for smaller articles (auger flights, drill rods, split spoons, etc.).

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location Establish the decontamination site far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or his/her designee, compliance with as many of the following characteristics as practicable:
 - Away from pedestrian/vehicle thoroughfares.
 - Avoidance of areas where control/custody cannot be maintained.
 - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.
 - Avoidance of potentially contaminated areas.
 - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

The selected decontamination site should include the following, where possible:

- Areas where potable water and electricity are provided.

Safety Reminder

When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:

- All power is routed through a Ground Fault Circuit Interrupter (GFCI).
- All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.

In situations where accomplishing these elements are not possible, it will be necessary to implement a site electrical grounding program.

- Areas where support activities such as removing decontamination waters, soil, and sediment are possible without entering an active exclusion zone.
- Areas that offer sufficient size to carry out the specific decontamination sequence.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 7 of 17
	Revision 8	Effective Date 07/15/2016

- Decontamination pad (decon pad) Construct the decontamination pad to meet the following characteristics:
 - Size The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size of the decontamination pad should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.
 - Slope An adequate slope should be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below. When preparing the pad, remove sticks, roots, stones, and debris that could puncture the liner. The area should be lightly graded and possibly covered with sand to minimize the possibility of puncture.
 - Sidewalls The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with plastic sheeting to control overspray.
 - Liner Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.
 - Wash/drying racks Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange, because dual tube or Macro-Core Samplers and drive rods require little space for decontamination

- Maintenance Maintain the decontamination area by:
 - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.
 - Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.
 - PPE Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 8 of 17
	Revision 8	Effective Date 07/15/2016

of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

- 7.1.2.1 During subsurface sampling activities including drilling and DPT activities, conduct decontamination of drive rods, Macro Core Samplers, split spoons, etc. at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.
- 7.1.2.2 Place buckets within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media.
- 7.1.2.3 Use drying racks where possible to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

- 7.1.3.1 When sampling at remote locations, evacuate sampling equipment such as trowels and pumps/tubing of potentially contaminated media to the extent possible.
- 7.1.3.2 Wrap this equipment in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition.
- 7.1.3.3 Flush and clean single-use equipment such as disposable trowels, tubing, and surgeon's gloves to allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

- 7.2.1.1 Groundwater sampling equipment This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.
- 1. Evacuate to the extent possible, any purge water within the pump/bailer.
- 2. Scrub the external components using soap and water and/or steam clean* the outside of the pump/bailer and, if applicable, the pump tubing.
- 3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.
- 4. Remove the pump and tubing/bailer from the container.
- 5. Rinse external pump components using tap water.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 9 of 17
	Revision 8	Effective Date 07/15/2016

6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

CAUTION

Do not rinse polyethylene (PE), PVC, and associated tubing with solvents – These are considered single use items and can be removed and disposed of after use. Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 should be omitted and tubing or plastic components replaced.

- 7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol. If groundwater contains these contaminants employ single use sampling apparatus that can be wash, rinsed, and disposed of after use.
- 8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.
- 9. Drain residual deionized water to the extent possible.
- 10. Allow components of the equipment to air dry.
- 11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect an equipment rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for equipment rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as ultraviolet light may be used.
- 12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

SAFETY REMINDER

Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 <u>Electronic Water Level Indicators/Sounders/Tapes</u>

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

- 1. Wash with soap and water
- 2. Rinse with tap water
- 3. Rinse with deionized water

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 10 of 17
	Revision 8	Effective Date 07/15/2016

NOTE

In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

7.2.1.3 <u>Miscellaneous Equipment</u>

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.
- Cleanliness As per protocol, only volatile organic samples are accompanied by a trip blank. If a
 cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler
 should be decontaminated prior to use as follows:
 - 1. Wash with soap and water
 - 2. Rinse with tap water
 - 3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

CAUTION

Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

- 1. Remove loose soil using shovels, scrapers, etc.
- 2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 11 of 17
	Revision 8	Effective Date 07/15/2016

CAUTION

In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

- 3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).
- 4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol

Note: Steam cleaning does the best job removing contaminants especially the more volatile components. Not only is the water pressure sufficient to remove caked on soils, the heat associated with the steam is very effective in removing contaminants (even those more stubborn ones such as PAHs and PCBs). Steam cleaning units, however, are more dangerous to use due to pressurized steam and water. Care must be taken to avoid thermal burns by ensuring all guards are in place and gloves are employed. When using steam, the items that have been washed dry relatively quickly because heated water and steam are applied.

- 5. To the extent possible, allow components to air dry.
- 6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.
- 7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

- <u>Falls</u> An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.
- <u>Burns</u> Steam cleaner water is heated to more than 212 °F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

<u>High water pressure</u> - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0° tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 15-25° fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 12 of 17
	Revision 8	Effective Date 07/15/2016

- Never point the pressure washer or steam cleaner at another person or use to clean your boots or other
 parts of your body. Water lacerations and burns may appear to be minor at first but can be life
 threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature
 or high-pressure water.
- 3. Always wear PPE as specified in the HASP (or equivalent) such as:
 - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.
- 4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.
- 5. Do not modify equipment unless the manufacturer has approved the modifications.

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

- 1. Remove all loose soil from the equipment through manual means.
- 2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.
- 3. Rinse the equipment with tap water.
- 4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol followed by steam cleaning. Where cleanliness is considered suspect, dispose and replace the suspect item.
- 5. Rinse the equipment with deionized water.
- 6. To the extent possible, allow components to air dry.
- 7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.
- 8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device. If sufficient surface water exists remove visible sediments by dunking within the water from where the sediment sample was obtained. Because of this always work from downstream to upstream
- Extract the dredge and wash it in soap and water per the project-specific planning documents.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 13 of 17
	Revision 8	Effective Date 07/15/2016

CAUTION

When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

Note: In all cases when cleaning stainless steel sampling equipment minimize if not eliminate the use of acids as this will leach certain metals (e.g., chromium, nickel, iron, and antimony) and may result in sample contamination. Use soap and water wash and rinse and, where necessary, steam clean to remove stubborn contaminants.

7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with project planning documents.

NOTE

Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

- 1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.
- 2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers); frac tanks, or tankers that can be sealed until ultimate disposal at an approved facility.

- **3.** Properly label waste storage containers (see Attachment A).
- **4.** Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:
 - Enclose areas accessible by the general public using construction fencing and signs.
 - Store materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
 - Maintain the retaining bolt and label on the outside of storage containers where readily visible.

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 14 of 17
	Revision 8	Effective Date 07/15/2016

- Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.
- As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.
- Maintain spill response equipment at the IDW storage area in case it is required for immediate access.
- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. These heavy objects may constitute a safety hazard. To minimize hazards such as this, limit the filling of drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties, and to allow for expansion caused by freezing. Use powered equipment as the preferred method for moving staging and disposal of IDW. Where this is not possible, use drum carts to move partially filled drums.

Where drums have to be manually handled:

Get help

Secure the drum to the cart

Clear the pathway to the staging area.

Employ safe lifting techniques.

Consult the Project Planning Documents, most importantly, the Activity Hazard Analysis for additional direction.

.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

Airborne Contaminant Exposure

To minimize potential airborne contaminant exposure close and seal all containers transported them inside the sampling support vehicle.

Periodically decontaminate temporary portable containers to minimize off-gassing inside the vehicle. When working at the well or storage container always work from an upwind position.

7.4 <u>Decontamination Evaluation</u>

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter.
 This shall be done to ensure that the washing/rinsing process is working as intended. Pay particular attention to points where soils and sediments may become trapped including threads cutting shoes to

Subject DECONTAMINATION OF FIELD EQUIPMENT	Number SA-7.1	Page 15 of 17
	Revision 8	Effective Date 07/15/2016

body, etc. It is often necessary to combine these types of decontamination methods to ensure the adequacy is sufficient to pass chemical rinsate.

• Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of equipment rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Equipment Rinsate Blanks It is recommended that equipment rinsate blank samples be collected to:
 - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.
 - Single-use disposable equipment The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.
 - The collection and the frequency of equipment rinsate blank samples are as follows unless specified differently in the project-specific planning documents:
 - Per decontamination method.
 - Per disposable article/batch number of disposable articles

NOTE

It is recommended that an initial equipment rinsate blank sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Equipment rinsate blank sample collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional equipment rinsate blank samples due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL supporting and/or resigning not to collect.



PR OS

OCEDURE	PERATING	TANDARD	
	7		

Effective Date	Number
7/15/2016	SA-7.1
Revision	Page
8	16 of 17

Inc., NUS Operating

Unit

Earth Sciences Department

Approved T. Johnston

ATTACHMENT

DECONTAMINATION OF FIELD EQUIPMENT AND MANAGEMENT OF INVESTIGATION DERIVED WASTE

IDW LABEL (EXAMPLE)

INVESTIGATION DERIVED WASTE **GENERATOR INFORMATION:** SITE _____ JOB NO. ____ LOCATION ____ DATE _____ DRUM# ____ CONTENTS _____ VOLUME _____ CONTACT ____ EMERGENCY PHONE NUMBER _____



Subject

DECONTAMINATION OF FIELD EQUIPMENT AND MANAGEMENT OF INVESTIGATION DERIVED WASTE

Approved T. Johnston

Prepared

Earth Sciences Department

Comments

PROCEDURE **OPERATING**

•	•					
Descord.	Tetra Tech, Inc., N	Applicability	7/15/2016	Effective Date	SA-7.1	Number
	Tetra Tech, Inc., NUS Operating Unit		8	Revision	17 of 17	Page

ATTACHMENT B, INVESTIGATIVE DERIVED WASTE DRUM/CONTAINER INVENTORY LOG (EXAMPLE)

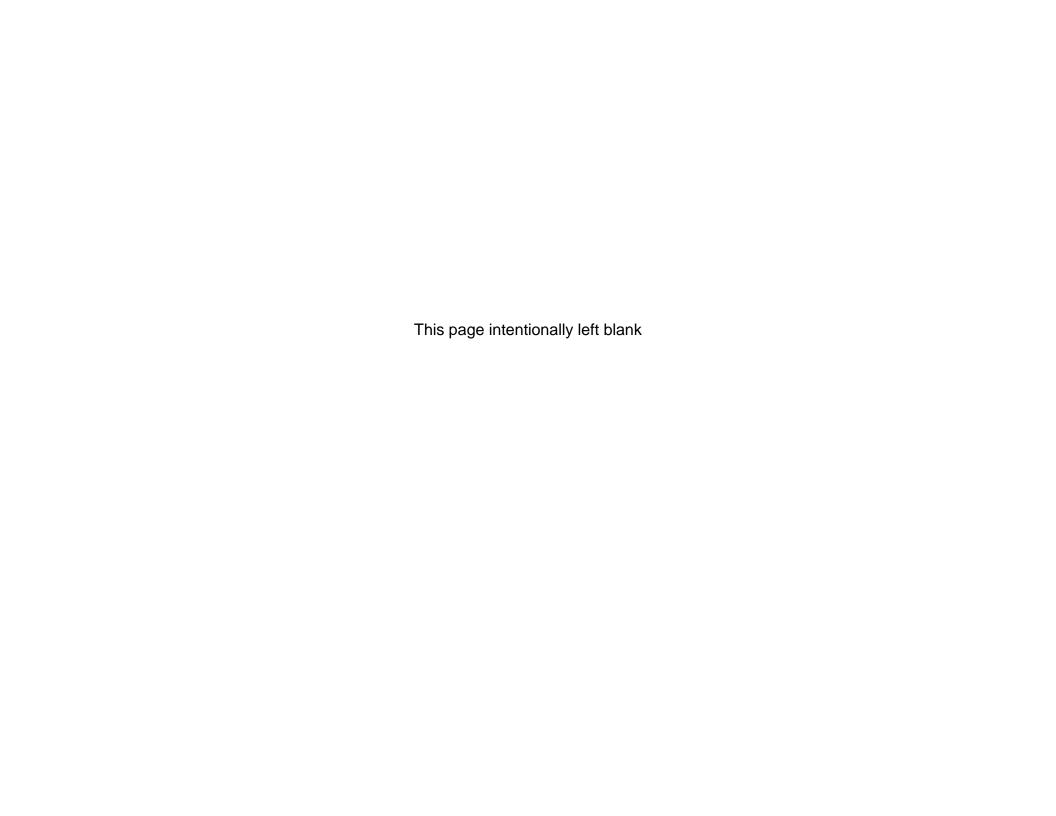
Location (SWMU and Estimated Volume

This attachment should be completed as investigative derived waste is accumulated. An updated inventory should be provided to the site Point of Contact at the end of each 10-day shift. Add additional rows on extra pages, as needed.

Drum/

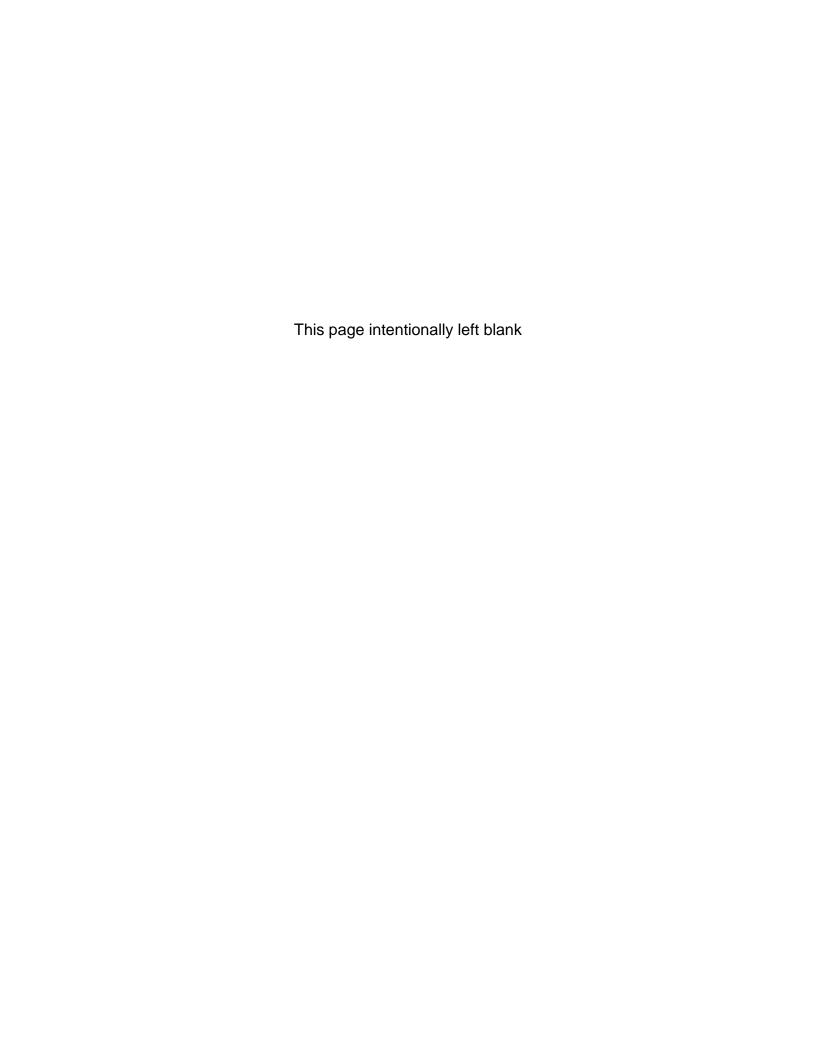
Media (Contents)

Number #	Type	Well#, etc.)		rilled	
1			()-Gallo	ns	
2			()-Gallo	ns	
3			()-Gallo	ns	
4			()-Gallo	ns	
mergency Point	of Contact	Phone Number	er:	0.00	
lame of Facility)	Point of Contact:	Phone Number	er: <u>()</u>		
formation Point	of Contact (Name):	Phone Number	er:		
		Contact, Phone Number: ()			
re Dept/Emerge	ncy Services Provider, Phor	e Number. ()			
omments:					



APPENDIX B

FIELD FORMS





CONTAINER SAMPLE & INSPECTION SHEET

	Page of
Project Site Name: Project Number: Site Identification:	Sample ID No Sampled By:
Container Number(s): Sample Type: [] Grab [] Composite	Concentration: [] High [] Medium [] Low
CONTAINER SOURCE	CONTAINER DESCRIPTION
DRUM: [] Bung Top [] Lever Lock	COLOR:
[] Bolted Ring [] Other	CONDITION:
TANK: [] Plastic	MARKINGS:
[] Metal [] Other	VOL. OF CONTENTS:
OTHER:	OTHER:
CONTAINER	CONTENTS
DISPOSITION	DESCRIPTION
SAMPLED:	SINGLE PHASED:
OPENED BUT NOT SAMPLED: Reason	MULTIPHASE : Layer 1 Layer 2 Layer 3
NOT OPENED:	Phase (Sol. or Liq.) Color Viscosity L, M or H L, M or H L, M orH
Reason	% of Total Volume
MONITOR READING:	SAMPLE and /or INSPECTION DATE & TIME:
	METHOD:
SAMPLER(S) and / or	ANALYSIS:
INSPECTOR(S) SIGNATURE:	



Tetra Tech

PROJECT:		JOB #:			
LOCATION:		DATE:			
PROJECT MANAGER:	FOL: _				
DAILY ACTIVIT	IES CHE	CKLIST			
Startup	Checklist				
Activity			Yes	No	N/A
Pertinent site activities/information entered into site logbook					
All onsite personnel listed in logbook					
Required medical information onsite for all workers (Tetra Te	ch and Subco	ontractors)			
Required MSDS's onsite					
Proper equipment calibrations performed (list equipment)					
1					
2					
3					
4					
Calibration logs filled out					
Tailgate H&S meeting held prior to beginning field activities					
Required work permits filled out/signed					
Required utility clearances obtained					
Required PPE onsite and in use					
Information required to be posted is in place					
(OSHA poster, hospital route, key phone numbers, e	etc.)				
Exit Cl	necklist				
Activity			Yes	No	N/A
Logbooks completely and comprehensively filled out			163	140	11//
Field forms complete and accounted for/properly filed					
Samples properly packaged/shipped					
COCs faxed to appropriate in-house personnel					
All equipment accounted for, on charge if needed, and prope	rly secured				
All personnel accounted for	ny occured				
Arrangements made for upcoming work (permits, clearances	equipment	etc.)			
Site properly secured	, oquipinoni,	O.O.,			
1 1 7					I

Note - not all items listed apply to every job, and some additional requirements may apply on a job-specific basis.

TETRA TECH	DAILY ACTIVITIES RECORD					
PROJECT NAME: CLIENT:		PROJECT NI	UMBER:			
DATE: TETRA TECH PERSONNEL:		ARRIVAL TII				
SUBCONTRACTOR:		DRILLER:				
ITEM	ITEM QUANTITY ESTIMATE					

COMMENTS:	
APPROVED BY:	
TETRA TECH REPRESENTATIVE	SUBCONTRACTOR



EQUIPMENT CALIBRATION LOG

PROJECT NAME :	INSTRUMENT NAME/MODEL:
SITE NAME:	MANUFACTURER:
PROJECT No.:	SERIAL NUMBER:

Date	Instrument	Person	Instrumen	Instrument Settings Instrument Readings		Readings	Calibration	Remarks
of	I.D.	Performing	Pre-	Post-	Pre-	Post-	Standard	and
Calibration	Number	Calibration	calibration	calibration	calibration	calibration	(Lot No.)	Comments



FIELD TASK MODIFICATION REQUEST FORM

Project/Installation Name	CTO & Project Nu	ımber	Task Mod. Numb	er
Modification To (e.g. Work Plan)	Site/Sample Loca		Date	
	One/Oample Loca	uion	Date	
Activity Description:				
Reason for Change:				
Barana da I Birana di				
Recommended Disposition:				
Requester, e.g., Field Operations Lea	der (Signature)	Date		
	(= 3)			
Approved Disposition:				
Project/Task Order Manager (Signatu	re)	Date		
Distribution:	-			
Program/Project File – Project/Task Order Manager – Field Operations Leader –	Ot	ther:		

GROUNDWATER LEVEL MEASUREMENT SHEET



Project Site Name:	
Project No.:	

Weather Cond	ditions:			Personnel:					
Tidally Influe	nced:	Yes	No		Measuring I				
Well or Piezometer No.	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments	

^{*} All measurements to the nearest 0.01 foot

GROUNDWATER SAMPLE LOG SHEET



Tt T	ETRA	ГЕСН				Event:						
							Project Site Name:					
							Project No.:					
Sample II	D:					Sampled	Bv:					
	uplicate ID:					Sample D						
	Collected:	YES	NO			Sample T						
WELL INFO	ORMATION:											
Well ID :						Purge Da	te:					
Well Dian	neter (in):						ter Level (ft	-BTOR):				
	creen (ft-BT	OR):					tor Reading					
	of Screen (ft-					Purge Me						
Total Wel	II Depth (ft-E	BTOR):				Sample M	lethod:					
EQUIPMEN	NT INFORM	ATION:										
Water Qu	ality Instrur	nent:				Pump Co	ntroller:					
Turbidity	Meter:											
PURGE DA	ATA:											
Time	H ₂ 0 Level	Flow	Color	pH	S.C.	DO (*****/)	Turbidity	Temp.	ORP	Salinity	Other	
(Hrs)	(ft-BTOR)	mL / min.		(S.U.)	(mS/cm)	(mg/L)	(NTU)	(C°)	(mV)	(% or ppt)		
FINAL PUR	RGE / SAMP	LE DATA:										
Start Purge	End Purge	Total (min.)	Total Vol. (gal. / L.)	pH (S.U.)	S.C. (mS/cm)	DO (mg/L)	Turbidity (NTU)	Temp. (C°)	ORP (mV)	Salinity (% or ppt)	Other	
	6, PRESERV	ATION AND		EQUIRMEN			1					
Ana	alysis		Method		Preser	vative	Number	Vol.	Bottle 1	Гуре	Collected	
						 						
OBSERVA	TIONS / NO	TES:										
0.	limataa.	_		_	-	Ciamat	(a):					



INSTRUMENT CALIBRATION LOGSHEET

PROJECT NAME : IN	NSTRUMENT NAME/MODEL:
SITE NAME: MA	IANUFACTURER:
PROJECT NO.:	ERIAL NUMBER:

Date of Calibration	Person Performing Calibration		рН	s.c	D.O.	Temp.	ORP	Salinity	Turbidity (1)	Turbidity (10)	Calibration Standard	Remarks
(mm/dd/yr)	(Initial)		(S.U.)	(mS/cm)	(mg/L)	°C	(mV)	(%)	(NTUs)	(NTUs)	Lot # / Expiration Date	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	
		Pre									Lot#	
		Post									Exp. Date:	



MONITORING WELL DEVELOPMENT RECORD

						Event: Project Site N Project Numb		Page of
Well No.: Drilling Co Date Insta Date Deve Dev. Meth Pump Typ Developed	lled: eloped: od: ee:			- - - - -	Casing ID (in Depth to Bott Static Water Static Water Screen Lengt Specific Capa	com (ft.): Level Before (Level After (ft. th (ft.):		
Time	Estimated Sediment Thickness (ft.)	Cumulative Water Volume (Gal.)	Water Level (ft. below TOC)	Temp. (C°)	pH (S.U.)	SC (mS/cm)	Turbidity (NTU)	Remarks: (odor, color, etc.)



SITE PHOTOGRAPHIC LOG

Date:	View:	Photographer:	Da	te:	View:	Photographer:
Date:	View:	Photographer:	Da	te:	View:	Photographer:

Site County, State



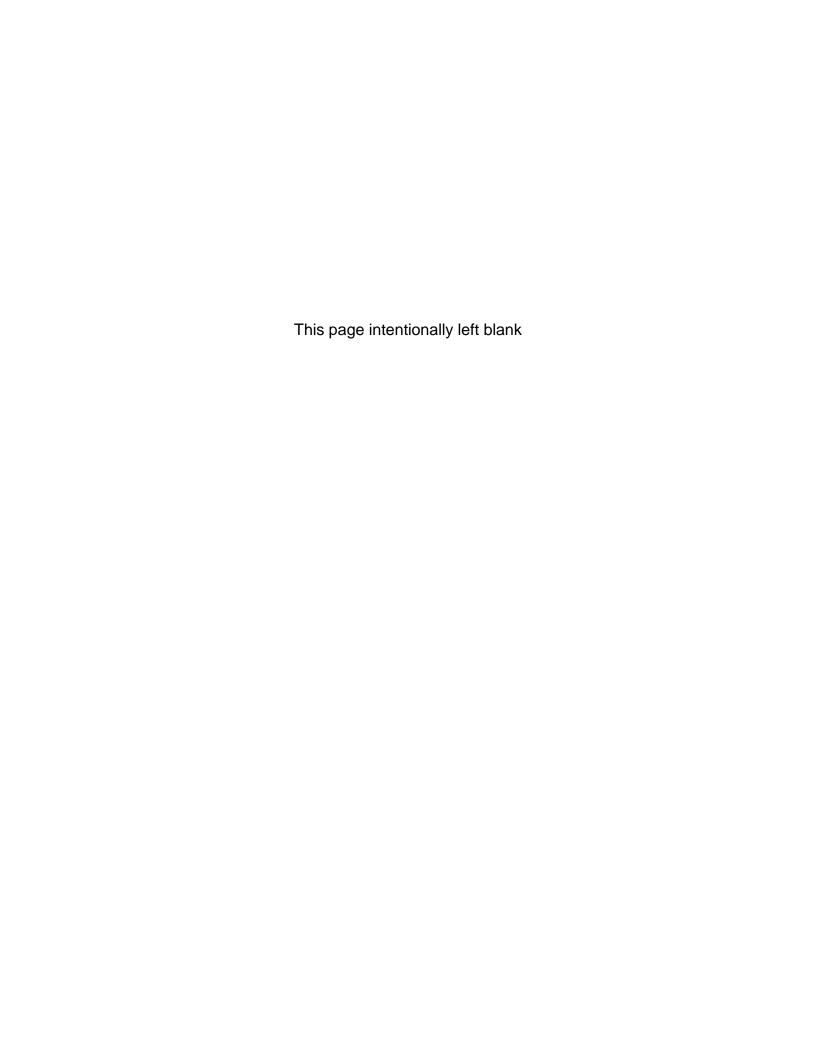
SITE PHOTOGRAPHIC LOG



Tetra Tech

PROJECT:	_ LOCATION:
	MOBILIZATION DATE:
PROJECT MANAGER:	
FIELD PROJECT PRE-M	OBILIZATION CHECKLIST
TRAVEL	MISCELLANEOUS
Airline reservations	Schedule
Hotel reservations/BOQs	Plan field operations w/ Project manager
Vehicle rental	Documents for Field Program
Itinerary	Logbook(s)
Phone/pager number DRILLING/DPT/SURVEY	Field Sampling plan
Subcontractor	Health & Safety plan
POC phone #/address	Maps H & S Guidance Manual
Drill Specification RFP	Authorization
Contact (time & place to meet)	Kick-off meeting held
Confirm subcontract w/ TtNUS Procurement	Gov't rate letter
Health and Safety documentation for all	H&S/OSHA 40-hour certifcate
personnel on site	8-Hour Refresher Training Certificate
Copy of Drillers license	Medical Clearance Letter
Well / boring permits	Supervisory Training Certificate
	Health & Safety Clearance Letter
Utilities (2 weeks lead time)	Full-size OSHA Poster HYDROGEOLOGY EQUIPMENT
Contact Site POC (Date:) Contact Local "Call Before You Dig"	Slug test/pumping test forms
Utility Clearance Form	Groundwater elevation data sheets
Forms	Graph paper
Boring logs / Test Pit logs	Data Logger/transducer/data cable
Well construction / development forms	Existing well construction & water level data
Daily activity forms	M-Scope, slug
IDW inventory IDW drum labels	SHIPPING Forms
Chemical Inventory	FedEx Airbills, local dropoff location & hours
MSDS's	FedEx Gov. Acct# (1771-8058-0)
EQUIPMENT MOBILIZATION	Lab Shipping Labels
Equipment Requisition form completed /	Warehouse Shipping Labels
equipment ordered	Blank Labels
3rd Party rental / misc. equipment ordered	
Equipment calibration forms	Supplies
Span / calibration gas and regulator	Tape
SAMPLING	Packing materials Baggies, Large garbage bags
Forms	OTHER
Sample log sheets	Site POC name/phone #
Low-flow purge data sheets	Personnel information to POC
COC records	Mobilization schedule to POC
COC seals	Site access authorizations
Sample labels (from database group)	Field office / trailer arrangements made
Laboratory	Electric, phone hookups arranged
POC address/phone#	Steel-toed boots, safety glasses, & hard hat
Order bottles / preservatives	First aid equipment
Shipping address, also check Sat. address	Insect repellent
Bottle & preservation req'ts from lab	
_	

APPENDIX C LABORATORY ACCREDITATION DOCUMENTATION





CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board

500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

Shealy Environmental Services, Inc. 106 Vantage Point Drive West Columbia, SC 29172

has been assessed by ANAB and meets the requirements of international standard

ISO/IEC 17025:2005

and DoD Quality Systems Manual for Environmental Laboratories (DoD QSM V 5.1.1)

while demonstrating technical competence in the fields of

TESTING

Refer to the accompanying Scope of Accreditation for information regarding the types of calibrations and/or tests to which this accreditation applies.

<u>L2224</u> Certificate Number

Version No. 007

ANAB Approval

Certificate Valid: 10/17/2018-11/18/2021

Issued: 10/17/2018





SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 AND DOD QUALITY SYSTEMS MANUAL FOR ENVIRONMENTAL LABORATORIES (DOD QSM V 5.1.1)

Shealy Environmental Services, Inc

106 Vantage Point Drive West Columbia, SC 29172 Wendy Plessinger 803-227-2705 x 104

TESTING

Valid to: November 18, 2021 Certificate Number: L2224

Environmental

Non-Potable Water		
Technology	Method	Analyte
GC	EPA 8151A	2,4,5-T
GC	EPA 8151A	2,4D
GC	EPA 8151A	2,4DB
GC	EPA 8151A	Dalapon
GC	EPA 8151A	Dicamba
GC	EPA 8151A	Dichloroprop
GC	EPA 8151A	Dinoseb
GC	EPA 8151A	MCPA
GC	EPA 8151A	MCPP
GC	EPA 8151A	Silvex(2,4,5 TP)
GC/MS	EPA 8270D	0,0,0-Triethylphosphorothioate
GC/MS	EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270D	1,2-Dichlorobenzene
GC/MS	EPA 8270D	1,3-Dichlorobenzene
GC/MS	EPA 8270D	1,3,5-Trinitrobenzene
GC/MS	EPA 8270D	1,4-Benzoquinone
GC/MS	EPA 8270D	1,4-Dichlorobenzene
GC/MS	EPA 8270D	1,4-Dinitrobenzene
GC/MS	EPA 8270D	1,4-Naphthoquinone







		table Water			
Technology	Method	Analyte			
GC/MS	EPA 8270D	1-Chloronaphthalene			
GC/MS	EPA 8270D	1-Methylnaphthalene			
GC/MS	EPA 8270D	1-Naphthylamine			
GC/MS	EPA 8270D	2,3, <mark>4,6-Tetrachlorophenol</mark>			
GC/MS	EPA 8270D	2,3,5,6-Tetrachlorophenol			
GC/MS	EPA 8270D	2,4,5-Trichlorophenol			
GC/MS	EPA 8270D	2,4,6-Trichlorophenol			
GC/MS	EPA 8270D	2,4-Dichlorophenol			
GC/MS	EPA 8270D	2,4-Dimethylphenol			
GC/MS	EPA 8270D	2,4-Dinitrophenol			
GC/MS	EPA 8270D	2,4-Dinitrotoluene			
GC/MS	EPA 8270D	2,6-Dichlorophenol			
GC/MS	EPA 8270D	2,6-Dinitrotoluene			
GC/MS	EPA 8270D	2-Acetylaminofluorene			
GC/MS	EPA 8270D	2-Chloronaphthalene			
GC/MS	EPA 8270D	2-Chlorophenol			
GC/MS	EPA 8270D	2-Methylnaphthalene			
GC/MS	EPA 8270D	2-Methylphenol			
GC/MS	EPA 8270D	2-Naphthylamine			
GC/MS	EPA 8270D	2-Nitroaniline			
GC/MS	EPA 8270D	2-Nitrophenol			
GC/MS	EPA 8270D	2-Picoline			
GC/MS	EPA 8270D	3,3'-Dichlorobenzidine			
GC/MS	EPA 8270D	3,3'-Dimethylbenzidine			
GC/MS	EPA 8270D	3-Methylcholanthrene			
GC/MS	EPA 8270D	3-Nitroaniline			
GC/MS	EPA 8270D	4,4'-Methylene-bis-chloroaniline			
GC/MS	EPA 8270D	4,6-Dinitro-2-methylphenol			
GC/MS	EPA 8270D	4-Aminobiphenyl			
GC/MS	EPA 8270D	4-Bromophenylphenylether			
GC/MS	EPA 8270D	4-Chloro-3-methylphenol			
GC/MS	EPA 8270D	4-Chloroaniline			
GC/MS	EPA 8270D	4-Chlorophenylphenylether			
GC/MS	EPA 8270D	4-Nitroaniline			
GC/MS	EPA 8270D	4-Nitrophenol			
GC/MS	EPA 8270D	5-Nitro-o-toluidine			

III ANAE



Non-Potable Water	n-Potable Water			
Technology	Method	Analyte		
GC/MS	EPA 8270D	7,12-Dimethylbenzo(a)anthracene		
GC/MS	EPA 8270D	Acenaphthene		
GC/MS	EPA 8270D	Ace <mark>nap</mark> hthylene		
GC/MS	EPA 8270D	Acetophenone		
GC/MS	EPA 8270D	Aniline		
GC/MS	EPA 8270D	Anthracene		
GC/MS	EPA 8270D	Aramite		
GC/MS	EPA 8270D	Atrazine		
GC/MS	EPA 8270D	Azobenzene		
GC/MS	EPA 8270D	Benzaldhyde		
GC/MS	EPA 8270D	Benzidine		
GC/MS	EPA 8270D	Benzo(a)Anthracene		
GC/MS	EPA 8270D	Benzo(a)pyrene		
GC/MS	EPA 8270D	Benzo(b)fluoranthene		
GC/MS	EPA 8270D	Benzo(g,h,i)perylene		
GC/MS	EPA 8270D	Benzo(k)fluoranthene		
GC/MS	EPA 8270D	Benzoic acid		
GC/MS	EPA 8270D	Benzyl alcohol		
GC/MS	EPA 8270D	Biphenyl		
GC/MS	EPA 8270D	bis(2-Chloroethoxy)methane		
GC/MS	EPA 8270D	bis(2-Chloroethyl)ether		
GCMS	EPA 8270D	Bis (2-Chloro-1-methylethyl) ether		
GC/MS	EPA 8270D	bis(2-Ethylhexyl)phthalate		
GC/MS	EPA 8270D	Butylbenzylphthalate		
GC/MS	EPA 8270D	Caprolactam		
GC/MS	EPA 8270D	Carbazole		
GC/MS	EPA 8270D	Chrysene		
GC/MS	EPA 8270D	Chlorobenzilate		
GC/MS	EPA 8270D	DEET		
GC/MS	EPA 8270D	Diallate		
GC/MS	EPA 8270D	Dibenzo(a,h)acridine		
GC/MS	EPA 8270D	Dibenzo(a,h)anthracene		
GC/MS	EPA 8270D	Dibenzo(a,e)pyrene		
GC/MS	EPA 8270D	Dibenzofuran		
GC/MS	EPA 8270D	Diethylphthalate		

IIICMRA ANAB



Potable Water			
Technology	Method	Analyte	
GC/MS	EPA 8270D	Dimethoate	
GC/MS	EPA 8270D	Dimethylphthalate	
GC/MS	EPA 8270D	Di-n-butylphthalate	
GC/MS	EPA 8270D	Di-n-octylphthalate	
GC/MS	EPA 8270D	Dinoseb	
GC/MS	EPA 8270D	Disulfoton	
GC/MS	EPA 8270D	Ethyl methacrylate	
GC/MS	EPA 8270D	Ethyl methanesulfonate	
GC/MS	EPA 8270D	Famphur	
GC/MS	EPA 8270D	Fluoranthene	
GC/MS	EPA 8270D	Fluorene	
GC/MS	EPA 8270D	Hexachlorobenzene	
GC/MS	EPA 8270D	Hexachlorobutadiene	
GC/MS	EPA 8270D	Hexachlorocyclopentadiene	
GC/MS	EPA 8270D	Hexachloroethane	
GC/MS	EPA 8270D	Hexachloropropene	
GC/MS	EPA 8270D	Indene	
GC/MS	EPA 8270D	Indeno(1,2,3-c,d)pyrene	
GC/MS	EPA 8270D	Isodrin	
GC/MS	EPA 8270D	Isophorone	
GC/MS	EPA 8270D	Isosafrole	
GC/MS	EPA 8270D	Kepone	
GC/MS	EPA 8270D	m+p-Cresol	
GC/MS	EPA 8270D	m-Dinitrobenzene	
GC/MS	EPA 8270D	Methyl methacrylate	
GC/MS	EPA 8270D	Methyl methanesulfonate	
GC/MS	EPA 8270D	Methyl parathion	
GC/MS	EPA 8270D	Mirex	
GC/MS	EPA 8270D	Naphthalene	
GC/MS	EPA 8270D	Nitrobenzene	
GC/MS	EPA 8270D	N-Nitrosodiethylamine	
GC/MS	EPA 8270D	N-Nitrosodimethylamine	
GC/MS	EPA 8270D	N-Nitrosodi-n-butylamine	
GC/MS	EPA 8270D	n-Nitroso-di-n-propylamine	
GC/MS	EPA 8270D	n-Nitrosodiphenylamine	
GC/MS	EPA 8270D	N-Nitrosomethylethylamine	

IIIC MRA ANAB



otable Water			
Technology	Method	Analyte	
GC/MS	EPA 8270D	N-Nitrosomorpholine	
GC/MS	EPA 8270D	N-N <mark>itr</mark> osopiperidine	
GC/MS	EPA 8270D	N-Nitrosopyrrolidine	
GC/MS	EPA 8270D	o-Cresol	
GC/MS	EPA 8270D	o-Toluidine	
GC/MS	EPA 8270D	p-(Dimethylamino)azobenzene	
GC/MS	EPA 8270D	Parathion	
GC/MS	EPA 8270D	Pentachlorobenzene	
GC/MS	EPA 8270D	Pentachloroethane	
GC/MS	EPA 8270D	Pentachloronitrobenzene	
GC/MS	EPA 8270D	Pentachlorophenol	
GC/MS	EPA 8270D	Phenacetin	
GC/MS	EPA 8270D	Phenanthrene	
GC/MS	EPA 8270D	Phenol	
GC/MS	EPA 8270D	Phorate	
GC/MS	EPA 8270D	Pronamide	
GC/MS	EPA 8270D	Pyrene	
GC/MS	EPA 8270D	Pyridine	
GC/MS	EPA 8270D	Quinoline	
GC/MS	EPA 8270D	Safrole	
GC/MS	EPA 8270D	Tetraethyl dithiopyrophosphate	
GC/MS	EPA 8270D	Thionazine	
GC/MS	EPA 8270D	Tributyl phosphate	
GC/MS	EPA 8270D SIM	Acenaphthene	
GC/MS	EPA 8270D SIM	Acenaphthylene	
GC/MS	EPA 8270D SIM	Anthracene	
GC/MS	EPA 8270D SIM	Benzo(a)anthracene	
GC/MS	EPA 8270D SIM	Benzo(a)pyrene	
GC/MS	EPA 8270D SIM	Benzo(b)fluoranthene	
GC/MS	EPA 8270D SIM	Benzo(g,h,i)perylene	
GC/MS	EPA 8270D SIM	Benzo(k)fluoranthene	
GC/MS	EPA 8270D SIM	Chrysene	
GC/MS	EPA 8270D SIM	Dibenz(a,h)anthracene	
GC/MS	EPA 8270D SIM	1,4-Dioxane	
GC/MS	EPA 8270D SIM	Fluoranthene	
GC/MS	EPA 8270D SIM	Fluorene	

III ANAB



	table Water			
Technology	Method	Analyte		
GC/MS	EPA 8270D SIM	Indeno(1,2,3-cd)pyrene		
GC/MS	EPA 8270D SIM	1-Methylphenol		
GC/MS	EPA 8270D SIM	2-Methylphenol		
GC/MS	EPA 8270D SIM	Na <mark>phtha</mark> lene		
GC/MS	EPA 8270D SIM	Pentachlorophenol		
GC/MS	EPA 8270D SIM	Phenanthrene		
GC/MS	EPA 8270D SIM	Pyrene		
GC/MS	EPA 625.1	Acenaphthene		
GC/MS	EPA 625.1	Acenaphthylene		
GC/MS	EPA 625.1	Aniline		
GC/MS	EPA 625.1	Anthracene		
GC/MS	EPA 625.1	Benzidine		
GC/MS	EPA 625.1	Benzo(a)anthracene		
GC/MS	EPA 625.1	Benzo(a)pyrene		
GC/MS	EPA 625.1	Benzo(b)fluoranthene		
GC/MS	EPA 625.1	Benzo(g,h,i)perylene		
GC/MS	EPA 625.1	Benzo(k)fluoranthene		
GC/MS	EPA 625.1	Benzoic acid		
GC/MS	EPA 625.1	Benzyl alcohol		
GC/MS	EPA 625.1	4-Bromophenyl phenyl ether		
GC/MS	EPA 625.1	Butyl benzyl phthalate		
GC/MS	EPA 625.1	Carbazole		
GC/MS	EPA 625.1	bis (2-Chloro-1-methylethyl) ether		
GC/MS	EPA 625.1	4-Chloro-3-methyl phenol		
GC/MS	EPA 625.1	4-Chloroaniline		
GC/MS	EPA 625.1	bis(2-Chloroethoxy)methane		
GC/MS	EPA 625.1	bis(2-Chloroethyl)ether		
GC/MS	EPA 625.1	2-Chloronaphthalene		
GC/MS	EPA 625.1	2-Chlorophenol		
GC/MS	EPA 625.1	4-Chlorophenyl phenyl ether		
GC/MS	EPA 625.1	Chrysene		
GC/MS	EPA 625.1	n-Decane		
GC/MS	EPA 625,1	Dibenzo(a,h)anthracene		
GC/MS	EPA 625.1	Dibenzofuran		
GC/MS	EPA 625.1	2,3-Dichloroaniline		
GC/MS	EPA 625.1	1,2-Dichlorobenzene		

IIIC MRA ANAB



-Potable Water			
Technology	Method	Analyte	
GC/MS	EPA 625.1	1,3-Dichlorobenzene	
GC/MS	EPA 625.1	1,4-Dichlorobenzene	
GC/MS	EPA 625.1	3,3'-Dichlorobenzidine	
GC/MS	EPA 625.1	2,4-Dichlorophenol	
GC/MS	EPA 625.1	2, <mark>6-Dich</mark> lorophenol	
GC/MS	EPA 625.1	Diethylphthalate	
GC/MS	EPA 625.1	Dimethyl phthalate	
GC/MS	EPA 625.1	3,3'-Dimethylbenzidine	
GC/MS	EPA 625.1	2,4-Dimethylphenol	
GC/MS	EPA 625.1	Di-n-butyl phthalate	
GC/MS	EPA 625.1	4,6-Dinitro-2-methylphenol	
GC/MS	EPA 625.1	2,4-Dinitrophenol	
GC/MS	EPA 625.1	2,4-Dinitrotoluene	
GC/MS	EPA 625.1	2,6-Dinitrotoluene	
GC/MS	EPA 625.1	Di-n-octylphthalate	
GC/MS	EPA 625.1	1,2-Diphenylhydrazine(as azobenzene)	
GC/MS	EPA 625.1	bis(2-Ethylhexyl)phthalate	
GC/MS	EPA 625.1	Fluoranthene	
GC/MS	EPA 625.1	Fluorene	
GC/MS	EPA 625.1	Hexachlorobenzene	
GC/MS	EPA 625.1	Hexachlorobutadiene	
GC/MS	EPA 625.1	Hexachlorocyclopentadiene	
GC/MS	EPA 625.1	Hexachloroethane	
GC/MS	EPA 625.1	Indeno(1,2,3-c,d)pyrene	
GC/MS	EPA 625.1	Isophorone	
GC/MS	EPA 625.1	1-Methylnaphthalene	
GC/MS	EPA 625.1	2-Methylnaphthalene	
GC/MS	EPA 625.1	2-Methylphenol	
GC/MS	EPA 625.1	3+4-Methylphenol	
GC/MS	EPA 625.1	N,N-Diethyl-m-toluamide (DEET)	
GC/MS	EPA 625.1	Naphthalene	
GC/MS	EPA 625.1	Nitrobenzene	
GC/MS	EPA 625,1	2-Nitrophenol	
GC/MS	EPA 625.1	4-Nitrophenol	
GC/MS	EPA 625.1	N-Nitrosodimethylamine	
GC/MS	EPA 625.1	N-Nitrosodi-n-propylamine	



Technology	Method	Analyte		
GC/MS	EPA 625.1	N-Nitrosodiphenylamine (Diphenylamine)		
GC/MS	EPA 625.1	n-Octadecane		
GC/MS	EPA 625.1	Pentach lorophenol		
GC/MS	EPA 625.1	Phe <mark>nanth</mark> rene		
GC/MS	EPA 625.1	Phenol		
GC/MS	EPA 625.1	Piperonyl butoxide (PIP)		
GC/MS	EPA 625.1	Pyrene		
GC/MS	EPA 625.1	alpha-Terpineol		
GC/MS	EPA 625.1	1,2,4-Trichlorobenzene		
GC/MS	EPA 625.1	2,4,6-Trichlorophenol		
GC/MS	EPA 8260B	1,1,1,2-Tetrachloroethane		
GC/MS	EPA 8260B	1,1,1-Trichloroethane		
GC/MS	EPA 8260B	1,1,2,2-Tetrachloroethene		
GC/MS	EPA 8260B	1,1,2-Trichloroethane		
GC/MS	EPA 8260B	1,1-Dichloroethane		
GC/MS	EPA 8260B	1,1-Dichloroethene		
GC/MS	EPA 8260B	1,1-Dichloropropene		
GC/MS	EPA 8260B	1,2,3-Trichlorobenzene		
GC/MS	EPA 8260B	1,2,3-Trichloropropane		
GC/MS	EPA 8260B	1,2,4-Trichlorobenzene		
GC/MS	EPA 8260B	1,2,4-Trimethylbenzene		
GC/MS	EPA 8260B	1,2-Dibromo-3-chloropropane		
GC/MS	EPA 8260B	1,2-Dibromoethane (EDB)		
GC/MS	EPA 8260B	1,2-Dichlorobenzene		
GC/MS	EPA 8260B	1,2-Dichloroethane		
GC/MS	EPA 8260B	1,2-Dichloropropane		
GC/MS	EPA 8260B	1,3,5-Trimethylbenzene		
GC/MS	EPA 8260B	1,3-Dichlorobenzene		
GC/MS	EPA 8260B	1,3-Dichloropropane		
GC/MS	EPA 8260B	1,4-Dichlorobenzene		
GC/MS	EPA 8260B	1,4-Dioxane		
GC/MS	EPA 8260B	2,2-Dichloropropane		
GC/MS	EPA 8260B	2-Butanone (MEK)		
GC/MS	EPA 8260B	2-Chloroethylvinyl ether		
GC/MS	EPA 8260B	2-Chlorotoluene		

Iac MRA ANAB



otable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B	3,3-Dimethyl-1-butanol
GC/MS	EPA 8260B	4-Chlorotoluene
GC/MS	EPA 8260B	4-Methyl-2-pentanone
GC/MS	EPA 8260B	Acetone
GC/MS	EPA 8260B	Acetonitrile
GC/MS	EPA 8260B	Acrolein
GC/MS	EPA 8260B	Acrylonitrile
GC/MS	EPA 8260B	Allyl chloride
GC/MS	EPA 8260B	Benzene
GC/MS	EPA 8260B	Benzyl chloride
GC/MS	EPA 8260B	Bromobenzene
GC/MS	EPA 8260B	Bromochloromethane
GC/MS	EPA 8260B	Bromodich loromethane
GC/MS	EPA 8260B	Bromoform
GC/MS	EPA 8260B	Bromomethane
GC/MS	EPA 8260B	Carbon disulfide
GC/MS	EPA 8260B	Carbon tetrachloride
GC/MS	EPA 8260B	Chlorobenzene
GC/MS	EPA 8260B	Chloroethane
GC/MS	EPA 8260B	Chloroform
GC/MS	EPA 8260B	Chloromethane
GC/MS	EPA 8260B	Chloroprene
GC/MS	EPA 8260B	cis-1,2-Dichloroethene
GC/MS	EPA 8260B	cis-1,3-Dichloropropene
GC/MS	EPA 8260B	Cyclohexane
GC/MS	EPA 8260B	Cyclohexanone
GC/MS	EPA 8260B	Dibromochloromethane
GC/MS	EPA 8260B	Dibromomethane
GC/MS	EPA 8260B	Dichlorodifluoromethane
GC/MS	EPA 8260B	Diisopropyl ether (IPE)
GC/MS	EPA 8260B	Ethanol
GC/MS	EPA 8260B	Ethyl ether
GC/MS	EPA 8260B	Ethyl methacrylate
GC/MS	EPA 8260B	Ethylbenzene
GC/MS	EPA 8260B	Ethyl-Tert-Butyl Ether
GC/MS	EPA 8260B	Freon 113

II ANAE



Method	
	Analyte
EPA 8260B	Hexachlorobutadiene
EPA 8260B	Isobutyl alcohol
EPA 8260B	Isop <mark>rop</mark> ylbenzene
EPA 8260B	m+p-Xylenes
EPA 8260B	Methacrylonitrile
EPA 8260B	Methyl Acetate
EPA 8260B	Methyl iodide
EPA 8260B	Methyl methacrylate
EPA 8260B	Methyl tertiary butyl ether (MTBE)
EPA 8260B	Methylcyclohexane
EPA 8260B	Methylene chloride
EPA 8260B	Naphthalene Naphthalene
EPA 8260B	n-Butylbenzene
EPA 8260B	n-Propylbenzene
EPA 8260B	o-Xylene
EPA 8260B	Pentachloroethane
EPA 8260B	p-Isopropyltoluene
EPA 8260B	Propionitrile
EPA 8260B	sec-Butylbenzene
EPA 8260B	Styrene
EPA 8260B	Tert-Amyl Alcohol (TAA)
EPA 8260B	Tert-Amyl Methyl Ether (TAME)
EPA 8260B	Tert-Butyl Alcohol (TBA)
EPA 8260B	Tert-Butyl Formate (TBF)
EPA 8260B	tert-Butylbenzene
EPA 8260B	Tetrachloroethene
EPA 8260B	Tetrahydrofuran
EPA 8260B	Toluene
EPA 8260B	Total Xylenes
EPA 8260B	trans-1,2-Dichloroethene
EPA 8260B	trans-1,3-Dichloropropene
EPA 8260B	trans-1,4-Dichloro-2-butene
EPA 8260B	Trichloroethene
EPA 8260B	Trichlorofluoromethane
EPA 8260B	Vinyl acetate
	EPA 8260B

III ANAE



Technology	Method	Analyte
GC/MS	EPA 8260B SIM	1,4-Dioxane
GC/MS	EPA 624.1	Acetone
GC/MS	EPA 624.1	Ace <mark>toni</mark> trile
GC/MS	EPA 624.1	Acrolein
GC/MS	EPA 624.1	Acrylonitrile
GC/MS	EPA 624.1	Benzene
GC/MS	EPA 624.1	Bromochloromethane
GC/MS	EPA 624.1	Bromodichloromethane
GC/MS	EPA 624.1	Bromoform
GC/MS	EPA 624.1	Bromomethane (Methyl bromide)
GC/MS	EPA 624.1	2-Butanone (MEK)
GC/MS	EPA 624.1	Carbon disulfide
GC/MS	EPA 624.1	Carbon tetrachloride
GC/MS	EPA 624.1	Chlorobenzene
GC/MS	EPA 624.1	Chloroethane
GC/MS	EPA 624.1	2-Chloroethylvinylether
GC/MS	EPA 624.1	Chloroform
GC/MS	EPA 624.1	Chloromethane (Methyl chloride)
GC/MS	EPA 624.1	Dibromochloromethane
GC/MS	EPA 624.1	1,2-Dibromoethane (EDB)
GC/MS	EPA 624.1	1,2-Dichlorobenzene
GC/MS	EPA 624.1	1,3-Dichlorobenzene
GC/MS	EPA 624.1	1,4-Dichlorobenzene
GC/MS	EPA 624.1	Dichlorodifluoromethane
GC/MS	EPA 624.1	1,1-Dichloroethane
GC/MS	EPA 624.1	1,2-Dichloroethane
GC/MS	EPA 624.1	1,1-Dichloroethene
GC/MS	EPA 624.1	cis-1,2-Dichloroethene
GC/MS	EPA 624.1	trans-1,2-Dichloroethene
GC/MS	EPA 624.1	1,2-Dichloropropane
GC/MS	EPA 624.1	cis-1,3-Dichloropropene
GC/MS	EPA 624.1	trans-1,3-Dichloropropene
GC/MS	EPA 624,1	Diisopropyl ether (IPE)
GC/MS	EPA 624.1	1,4-Dioxane
GC/MS	EPA 624.1	Ethylbenzene
GC/MS	EPA 624.1	Methyl methacrylate

III ANAE



Technology	Method	Analyte
GC/MS	EPA 624.1	Methyl tertiary butyl ether (MTBE)
GC/MS	EPA 624.1	Met <mark>hyl</mark> ene chloride
GC/MS	EPA 624.1	Nap <mark>hth</mark> alene
GC/MS	EPA 624.1	Styrene
GC/MS	EPA 624.1	1,1,2,2-Tetrachloroethane
GC/MS	EPA 624.1	Tetrachloroethene
GC/MS	EPA 624.1	Toluene
GC/MS	EPA 624.1	1,2,4-Trichlorobenzene
GC/MS	EPA 624.1	1,1,1-Trichloroethane
GC/MS	EPA 624.1	1,1,2-Trichloroethane
GC/MS	EPA 624.1	Trichloroethene
GC/MS	EPA 624.1	Trichlorofluoromethane
GC/MS	EPA 624.1	1,2,4-Trimethylbenzene
GC/MS	EPA 624.1	1,3,5-Trimethylbenzene
GC/MS	EPA 624.1	Vinyl acetate
GC/MS	EPA 624.1	Vinyl chloride
GC/MS	EPA 624.1	Xylenes (total)
GC/MS	SM 6200B-2011	Benzene
GC/MS	SM 6200B-2011	Bromobenzene
GC/MS	SM 6200B-2011	Bromochloromethane
GC/MS	SM 6200B-2011	Bromodichloromethane
GC/MS	SM 6200B-2011	Bromoform
GC/MS	SM 6200B-2011	Bromomethane (Methyl bromide)
GC/MS	SM 6200B-2011	n-Butylbenzene
GC/MS	SM 6200B-2011	sec-Butylbenzene
GC/MS	SM 6200B-2011	tert-Butylbenzene
GC/MS	SM 6200B-2011	Carbon tetrachloride
GC/MS	SM 6200B-2011	Chlorobenzene
GC/MS	SM 6200B-2011	Chloroethane
GC/MS	SM 6200B-2011	Chloroform
GC/MS	SM 6200B-2011	Chloromethane (Methyl chloride)
GC/MS	SM 6200B-2011	2-Chlorotoluene
GC/MS	SM 6200B-2011	4-Chlorotoluene
GC/MS	SM 6200B-2011	Dibromochloromethane
GC/MS	SM 6200B-2011	1,2-Dibromoethane (EDB)
GC/MS	SM 6200B-2011	Dibromomethane (Methylene bromide)





Technology Method GC/MS SM 6200B-2011 1,2-Dichloroben GC/MS SM 6200B-2011 1,3-Dichloroben GC/MS SM 6200B-2011 1,4-Dichloroben GC/MS SM 6200B-2011 Dichlorodifluoro GC/MS SM 6200B-2011 1,1-Dichloroetha GC/MS SM 6200B-2011 1,2-Dichloroetha GC/MS SM 6200B-2011 1,1-Dichloroetha GC/MS SM 6200B-2011 1,1-Dichloroetha	
GC/MS SM 6200B-2011 1,3-Dichloroben GC/MS SM 6200B-2011 1,4-Dichloroben GC/MS SM 6200B-2011 Dichlorodifluoro GC/MS SM 6200B-2011 1,1-Dichloroetha GC/MS SM 6200B-2011 1,2-Dichloroetha GC/MS SM 6200B-2011 1,2-Dichloroetha	
GC/MS SM 6200B-2011 1,4-Dichloroben GC/MS SM 6200B-2011 Dichlorodifluoro GC/MS SM 6200B-2011 1,1-Dichloroetha GC/MS SM 6200B-2011 1,2-Dichloroetha	izene
GC/MS SM 6200B-2011 Dichlorodifluoro GC/MS SM 6200B-2011 1,1-Dichloroetha GC/MS SM 6200B-2011 1,2-Dichloroetha	· ·
GC/MS SM 6200B-2011 1,1-Dichloroetha GC/MS SM 6200B-2011 1,2-Dichloroetha	izene
GC/MS SM 6200B-2011 1,2-Dichloroetha	omethane
12 2 22 2 7 7 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	ane
GC/MS SM 6200B-2011 1,1-Dichloroethe	ane
	ene
GC/MS SM 6200B-2011 cis-1,2-Dichloro	pethene
GC/MS SM 6200B-2011 trans-1,2-Dichlo	proethene
GC/MS SM 6200B-2011 1,2-Dichloropro	pane
GC/MS SM 6200B-2011 1,3-Dichloropro	pane
GC/MS SM 6200B-2011 2,2-Dichloropro	pane
GC/MS SM 6200B-2011 1,1-Dichloropro	pene
GC/MS SM 6200B-2011 cis-1,3-Dichloro	propene
GC/MS SM 6200B-2011 trans-1,3-Dichlo	propropene
GC/MS SM 6200B-2011 Diisopropyl ethe	er (IPE)
GC/MS SM 6200B-2011 Ethylbenzene	
GC/MS SM 6200B-2011 Hexachlorobutad	diene
GC/MS SM 6200B-2011 Isopropylbenzen	ne (Cumene)
GC/MS SM 6200B-2011 p-Isopropyltolue	ene (p-Cymene)
GC/MS SM 6200B-2011 Methyl tertiary b	butyl ether (MTBE)
GC/MS SM 6200B-2011 4-Methyl-2-pent	tanone
GC/MS SM 6200B-2011 Methylene chlor	ride
GC/MS SM 6200B-2011 Naphthalene	
GC/MS SM 6200B-2011 n-Propylbenzene	e
GC/MS SM 6200B-2011 Styrene	
GC/MS SM 6200B-2011 1,1,1,2-Tetrachlo	oroethane
GC/MS SM 6200B-2011 1,1,2,2-Tetrachle	oroethane
GC/MS SM 6200B-2011 Tetrachloroether	ne
GC/MS SM 6200B-2011 Toluene	
GC/MS SM 6200B-2011 1,1,2-Trichloro-	1,2,2-Trifluoroethane
GC/MS SM 6200B-2011 1,2,3-Trichlorob	penzene
GC/MS SM 6200B-2011 1,2,4-Trichlorob	penzene
GC/MS SM 6200B-2011 1,1,1-Trichloroe	thane
GC/MS SM 6200B-2011 1,1,2-Trichloroe	thane
GC/MS SM 6200B-2011 Trichloroethene	

III ANAB



Technology	Method	Analyte	
GC/MS	SM 6200B-2011	Trichlorofluoromethane	
GC/MS	SM 6200B-2011	1,2,3-Trichloropropane	
GC/MS	SM 6200B-2011	1,3, <mark>5-Tr</mark> imethylbenzene (Mesitylene)	
GC/MS	SM 6200B-2011	1,2, <mark>4-Tri</mark> methylbenzene	
GC/MS	SM 6200B-2011	Vinyl chloride	
GC/MS	SM 6200B-2011	m+p - Xylenes	
GC/MS	SM 6200B-2011	o-Xylene	
GC	EPA 8081B	4,4'-DDD	
GC	EPA 8081B	4,4'-DDE	
GC	EPA 8081B	4,4'-DDT	
GC	EPA 8081B	Aldrin	
GC	EPA 8081B	alpha-BHC	
GC	EPA 8081B	alpha-Chlordane	
GC	EPA 8081B	beta-BHC	
GC	EPA 8081B	Chlordane	
GC	EPA 8081B	delta-BHC	
GC	EPA 8081B	Dieldrin	
GC	EPA 8081B	Endosulfan I	
GC	EPA 8081B	Endosulfan II	
GC	EPA 8081B	Endosulfan sulfate	
GC	EPA 8081B	Endrin	
GC	EPA 8081B	Endrin Aldehyde	
GC	EPA 8081B	Endrin Ketone	
GC	EPA 8081B	gamma-BHC (Lindane)	
GC	EPA 8081B	gamma-Chlordane	
GC	EPA 8081B	Heptachlor	
GC	EPA 8081B	Heptachlor Epoxide	
GC	EPA 8081B	Methoxychlor	
GC	EPA 8081B	Mirex	
GC	EPA 8081B	Toxaphene	
GC	EPA 8082A	Aroclor 1016	
GC	EPA 8082A	Aroclor 1221	
GC	EPA 8082A	Aroclor 1232	
GC	EPA 8082A	Aroclor 1242	
GC	EPA 8082A	Aroclor 1248	
GC	EPA 8082A	Aroclor 1254	



on-Potable Water		
Technology	Method	Analyte
GC	EPA 8082A	Aroclor 1260
GC	EPA 8082A	Aroclor 1262
GC	EPA 8082A	Aroclor 1268
GC	EPA 608.3	Aldrin
GC	EPA 608.3	ga <mark>mma-B</mark> HC (Lindane)
GC	EPA 608.3	alpha-BHC
GC	EPA 608.3	beta-BHC
GC	EPA 608.3	delta-BHC
GC	EPA 608.3	Chlordane
GC	EPA 608.3	cis-Chlordane
GC	EPA 608.3	trans-Chlordane
GC	EPA 608.3	4,4'-DDD
GC	EPA 608.3	4,4'-DDE
GC	EPA 608.3	4,4'-DDT
GC	EPA 608.3	Dieldrin
GC	EPA 608.3	Endosulfan I
GC	EPA 608.3	Endosulfan II
GC	EPA 608.3	Endosulfan sulfate
GC	EPA 608.3	Endrin
GC	EPA 608.3	Endrin aldehyde
GC	EPA 608.3	Endrin ketone
GC	EPA 608.3	Heptachlor
GC	EPA 608.3	Heptachlor epoxide
GC	EPA 608.3	Methoxychlor
GC	EPA 608.3	Toxaphene
GC	EPA 608.3	Aroclor 1016
GC	EPA 608.3	Aroclor 1221
GC	EPA 608.3	Aroclor 1232
GC	EPA 608.3	Aroclor 1242
GC	EPA 608.3	Aroclor 1248
GC	EPA 608.3	Aroclor 1254
GC	EPA 608.3	Aroclor 1260
HPLC	EPA 8330A	2-Amino-4,6-dinitrotoluene
HPLC	EPA 8330A	4-Amino-2,6-dinitrotoluene
HPLC	EPA 8330A	1,3-Dinitrobenzene
HPLC	EPA 8330A	2,4-Dinitrotoluene

III ANAE



Non-Potable Water	on-Potable Water		
Technology	Method	Analyte	
HPLC	EPA 8330A	2,6-Dinitrotoluene	
HPLC	EPA 8330A	HMX	
HPLC	EPA 8330A	Nitrobenzene	
HPLC	EPA 8330A	2-Nitrotoluene	
HPLC	EPA 8330A	3-Nitrotoluene	
HPLC	EPA 8330A	4-Nitrotoluene	
HPLC	EPA 8330A	RDX	
HPLC	EPA 8330A	Tetryl	
HPLC	EPA 8330A	1,3,5-Trinitrobenzene	
HPLC	EPA 8330A	2,4,6-Trinitrotoluene	
HPLC	EPA 8330B	2-Amino-4,6-dinitrotoluene	
HPLC	EPA 8330B	4-Amino-2,6-dinitrotoluene	
HPLC	EPA 8330B	1,3-Dinitrobenzene	
HPLC	EPA 8330B	2,4-Dinitrotoluene	
HPLC	EPA 8330B	2,6-Dinitrotoluene	
HPLC	EPA 8330B	HMX	
HPLC	EPA 8330B	Nitrobenzene	
HPLC	EPA 8330B	Nitroglycerin (NG)	
HPLC	EPA 8330B	2-Nitrotoluene	
HPLC	EPA 8330B	3-Nitrotoluene	
HPLC	EPA 8330B	4-Nitrotoluene	
HPLC	EPA 8330B	RDX	
HPLC	EPA 8330B	Tetryl	
HPLC	EPA 8330B	1,3,5-Trinitrobenzene	
HPLC	EPA 8330B	2,4,6-Trinitrotoluene	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Fluorotelomer sulfonate 8:2 [1H,1H,2H,2H-perfluorodecane sulfonate] (8:2 FTS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Fluorotelomer sulfonate 4:2 [1H,1H,2H,2H-perfluorohexane sulfonate] (4:2 FTS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Fluorotelomer sulfonate 6:2 [1H,1H,2H,2H-perfluorooctane sulfonate] (6:2 FTS	

Iac MRA ANAB



Non-Potable Water		
Technology	Method	Analyte
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	GenX (HFPO-DA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-butanesulfonate (PFBS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-butanoic acid (PFBA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-decanesulfonate (PFDS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-decanoic acid (PFDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-dodecanoic acid (PFDoA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-heptanesulfonate (PFHpS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-heptanoic acid (PFHpA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-hexanesulfonate (PFHxS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-hexanoic acid (PFHxA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-nonanesulfonate (PFNS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-nonanoic acid (PFNA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctanesulfonate (PFOS)



Non-Potable Water		
Technology	Method	Analyte
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-octanesulfonamide (PFOSA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-octanoic acid (PFOA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-pentanoic acid (PFPeA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-pentansulfonate (PFPeS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-tetradecanoic acid (PFTeDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-tridecanoic acid (PFTrDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-undecanoic acid (PFUDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-methylperfluoro-1-octanesulfonamide (MeFOSA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-ethylperfluoro-1-octanesulfonamide (EtFOSA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	1H,1H,2H,2H-perfluorododecane sulfonate (10:2FTS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-butanoic acid (PFBA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-pentanoic acid (PFPeA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-heptanoic acid (PFHpA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorohexanesulfonate (PFHxS)

IIIC MRA ANAB



Non-Potable Water		
Technology	Method	Analyte
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-octanoic acid (PFOA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-nonanoic acid (PFNA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctanesulfonate (PFOS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-decanoic acid (PFDA)
GC	EPA 8015C	Diesel Range Organics
GC	EPA 8015C	WI-Diesel Range Organics
GC	EPA 8015C	Gasoline Range Organics
GC	EPA 8015C	WI-Gasoline Range Organics
GC	RSK - 175	Methane, Ethane, Ethene
GC	EPA 8011	1,2-Dibromoethane (EDB)
GC	EPA 8011	1,2-Dibromo-3-chloropropane (DBCP)
GC	FL-PRO	FL-PRO
ICP	EPA 6010D	Aluminum
ICP	EPA 6010D	Antimony
ICP	EPA 6010D	Arsenic
ICP	EPA 6010D	Barium
ICP	EPA 6010D	Beryllium
ICP	EPA 6010D	Cadmium
ICP	EPA 6010D	Calcium
ICP	EPA 6010D	Chromium
ICP	EPA 6010D	Cobalt
ICP	EPA 6010D	Copper
ICP	EPA 6010D	Iron
ICP	EPA 6010D	Lead
ICP	EPA 6010D	Magnesium
ICP	EPA 6010D	Manganese
ICP	EPA 6010D	Molybdenum
ICP	EPA 6010D	Nickel
ICP	EPA 6010D	Potassium
ICP	EPA 6010D	Selenium

IAC MRA ANAE



Potable Water		
Technology	Method	Analyte
ICP	EPA 6010D	Silver
ICP	EPA 6010D	Sodium
ICP	EPA 6010D	Thallium
ICP	EPA 6010D	Tin
ICP	EPA 6010D	Vanadium
ICP	EPA 6010D	Zinc
ICP/MS	EPA 200.8	Aluminum
ICP/MS	EPA 200.8	Antimony
ICP/MS	EPA 200.8	Arsenic
ICP/MS	EPA 200.8	Barium
ICP/MS	EPA 200.8	Beryllium
ICP/MS	EPA 200.8	Boron
ICP/MS	EPA 200.8	Cadmium
ICP/MS	EPA 200.8	Calcium
ICP/MS	EPA 200.8	Chromium
ICP/MS	EPA 200.8	Cobalt
ICP/MS	EPA 200.8	Copper
ICP/MS	EPA 200.8	Iron
ICP/MS	EPA 200.8	Lead
ICP/MS	EPA 200.8	Magnesium
ICP/MS	EPA 200.8	Manganese
ICP/MS	EPA 200.8	Molybdenum
ICP/MS	EPA 200.8	Nickel
ICP/MS	EPA 200.8	Potassium
ICP/MS	EPA 200.8	Selenium
ICP/MS	EPA 200.8	Silicon
ICP/MS	EPA 200.8	Silver
ICP/MS	EPA 200.8	Sodium
ICP/MS	EPA 200.8	Thallium
ICP/MS	EPA 200.8	Tin
ICP/MS	EPA 200.8	Titanium
ICP/MS	EPA 200.8	Vanadium
ICP/MS	EPA 200.8	Zinc
ICP/MS	EPA 6020B	Aluminum
ICP/MS	EPA 6020B	Antimony
ICP/MS	EPA 6020B	Arsenic

III ANAB



Non-Potable Water		
Technology	Method	Analyte
ICP/MS	EPA 6020B	Barium
ICP/MS	EPA 6020B	Beryllium
ICP/MS	EPA 6020B	Cadmium
ICP/MS	EPA 6020B	Calcium
ICP/MS	EPA 6020B	Chromium
ICP/MS	EPA 6020B	Cobalt
ICP/MS	EPA 6020B	Copper
ICP/MS	EPA 6020B	Iron
ICP/MS	EPA 6020B	Lead
ICP/MS	EPA 6020B	Magnesium
ICP/MS	EPA 6020B	Manganese
ICP/MS	EPA 6020B	Nickel
ICP/MS	EPA 6020B	Potassium
ICP/MS	EPA 6020B	Selenium
ICP/MS	EPA 6020B	Silver
ICP/MS	EPA 6020B	Sodium
ICP/MS	EPA 6020B	Thallium
ICP/MS	EPA 6020B	Tin
ICP/MS	EPA 6020B	Vanadium
ICP/MS	EPA 6020B	Zinc
CVAA	EPA 1631E	Low Level Mercury
CVAA	EPA 7470A / EPA 245.1	Mercury
Gravimetric	EPA 1664B	Oil & Grease
Titration	SM 2320B-2011	Alkalinity
Calculation	SM 2320B-2011	Biçarbonate Alkalinity
Calculation	SM 2320B-2011	Carbonate Alkalinity
Calculation	SM 2320B-2011	Hydroxide Alkalinity
Calculation	SM 4500-CO2 D	Carbon Dioxide (CO2)
Photometric	SM 2120F-2011	Color
Photometric	SM 2120B-2011	Platinum Cobalt Color
UV/VIS	SM 3500-Fe B-2011	Ferrous Iron
Titration	SM 4500-S2 F-2011	Sulfide
Wet Oxidation	EPA 9060A	TOC
Wet Oxidation	SM 5310C-2011	TOC
Titration	SM 2340C-2011	Total Hardness

IAC MRA ANAE



Non-Potable Water		
Technology	Method	Analyte
Filtration	SM 2540C-2011	Total Dissolved Solids (TDS)
Filtration	SM 2540D-2011	Total Suspended Solids (TSS)
UV/VIS	SM 4500-CN E-2011	Total Cyanide
UV/VIS	EPA 9012B	Total Cyanide
UV/VIS	EPA 9065	Phenolics
UV/VIS	EPA 9066	Phenolics
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Chloride
IC	EPA 9056A	Sulfate
IC	EPA 9056A	Bromide
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 300.0	Fluoride
IC	EPA 300.0	Chloride
IC	EPA 300.0	Sulfate
IC	EPA 300.0	Bromide
IC	EPA 300.0	Nitrate
IC	EPA 300.0	Nitrite
IC	EPA 218.6	Hexavalent chromium
IC	EPA 7199	Hexavalent chromium
UV/VIS	EPA 7196A	Hexavalent chromium
Discrete Analyzer	SM 3500-Cr B-2011	Hexavalent chromium
Pensky-Martens	EPA 1010A	Ignitability
Electrode	EPA 9040C	Corrosivity
Electrode	SM 4500-H B-2011	Corrosivity
Electrode	EPA 120.1	Specific Conductance
Electrode	EPA 180.1	Turbidity
Titration	Sec. 7.3.3 SW-846	Reactive Cyanide
Photometric	Sec. 7.3.4 SW-846	Reactive Sulfide
UV/VIS	EPA 353.2	Nitrate
UV/VIS	EPA 353.2	Nitrite
UV/VIS	EPA 353.2	Nitrate-Nitrite
UV/VIS	EPA 365.1	Phosphorus/ Orthophosphate

org lac MRA AN



Non-Potable Water		
Technology	Method	Analyte
UV/VIS	EPA 350.1	Ammonia
Gas Diffusion / UV/VIS	EPA 350.1	Am <mark>mo</mark> nia - N
UV/VIS	EPA 351.2	TKN
UV/VIS	SM 5220D-2011	COD
GC	MADEP-EPH-MOD	Extractable Petroleum Hydrocarbons (EPH) Modified
GC	MADEP-VPH-MOD	Volatile Petroleum Hydrocarbons (VPH) Modified
Preparation	Method	Туре
Organic Preparation	EPA 3520C	Organic Prep. of Water by Continuous Liquid-Liquid
Organic Preparation	EPA 3535A	Solid-Phase Extraction (SPE)
Organic Cleanup	EPA 3620B	Florisil Cleanup Procedure
Organic Cleanup	EPA 3660B	Sulfur Cleanup Procedure
Organic Cleanup	EPA 3665A	Sulfuric Acid Cleanup Procedure
Waste Dilution	EPA 3580A	Waste Dilution
Volatile Organic Preparation	EPA 5030B	Purge-and-Trap for Aqueous Samples
Volatile Organic Preparation	EPA 5035	Closed-System Purge-and-Trap and extraction for Volatile Organics in Soil and Waste Samples
Volatile Organic Preparation	EPA 3585	Waste Dilution for Volatile Organics
Inorganic Preparation	EPA 3005A	Preparation of Waters by Hotblock
Inorganic Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure (TCLP)
Inorganic Metals Preparation	EPA 3010A	Acid Digestion of Aqueous Samples and TCLP/SPLP Extracts for ICP analysis
Inorganic Metals Preparation	EPA 3030C	Acid Digestion of Aqueous Samples for ICP Spectroscopy
Organic Cleanup	EPA 3640	GPC Cleanup Procedure

Solid and Chemical Materials			
Technology	Method	Analyte	
GC	EPA 8151A	Dalapon	
GC	EPA 8151A	Dicamba	
GC	EPA 8151A	Dichloroprop	
GC	EPA 8151A	MCPP	
GC	EPA 8151A	MCPA	
GC	EPA 8151A	2,4D	





and Chemical Materials		
Technology	Method	Analyte
GC	EPA 8151A	Silvex(2,4,5 TP)
GC	EPA 8151A	2,4, <mark>5-T</mark>
GC	EPA 8151A	2,4DB
GC	EPA 8151A	Dinoseb
GC/MS	EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270D	1,2-Dichlorobenzene
GC/MS	EPA 8270D	1,3-Dichlorobenzene
GC/MS	EPA 8270D	1,4-Dichlorobenzene
GC/MS	EPA 8270D	1-Methylnaphthalene
GC/MS	EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 8270D	2,4-Dinitrotoluene
GC/MS	EPA 8270D	2,6-Dichlorophenol
GC/MS	EPA 8270D	2,6-Dinitrotoluene
GC/MS	EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 8270D	2-Chlorophenol
GC/MS	EPA 8270D	2-Methylnaphthalene
GC/MS	EPA 8270D	2-Methylphenol
GC/MS	EPA 8270D	2-Nitroaniline
GC/MS	EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	3,3'-Dichlorobenzidine
GC/MS	EPA 8270D	3,3'-Dimethylbenzidine
GC/MS	EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270D	4-Bromophenylphenylether
GC/MS	EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270D	4-Chloroaniline
GC/MS	EPA 8270D	4-Chlorophenylphenylether
GC/MS	EPA 8270D	4-Nitroaniline
GC/MS	EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	Acenaphthene





and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8270D	Acenaphthylene
GC/MS	EPA 8270D	Acetophenone
GC/MS	EPA 8270D	Ant <mark>hrac</mark> ene
GC/MS	EPA 8270D	Atrazine
GC/MS	EPA 8270D	Azobenzene
GC/MS	EPA 8270D	Benzaldhyde
GC/MS	EPA 8270D	Benzidine
GC/MS	EPA 8270D	Benzo(a)Anthracene
GC/MS	EPA 8270D	Benzo(a)pyrene
GC/MS	EPA 8270D	Benzo(b)fluoranthene
GC/MS	EPA 8270D	Benzo(g,h,i)perylene
GC/MS	EPA 8270D	Benzo(k)fluoranthene
GC/MS	EPA 8270D	Benzoic acid
GC/MS	EPA 8270D	Benzyl alcohol
GC/MS	EPA 8270D	Biphenyl
GC/MS	EPA 8270D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270D	bis(2-Chloroethyl)ether
GCMS	EPA 8270D	Bis (2-Chloro-1-methylethyl) ether
GC/MS	EPA 8270D	bis(2-Ethylhexyl)phthalate
GC/MS	EPA 8270D	Butylbenzylphthalate
GC/MS	EPA 8270D	Caprolactam
GC/MS	EPA 8270D	Carbazole
GC/MS	EPA 8270D	Chrysene
GC/MS	EPA 8270D	DEET
GC/MS	EPA 8270D	Dibenzo(a,h)anthracene
GC/MS	EPA 8270D	Dibenzofuran
GC/MS	EPA 8270D	Diethylphthalate
GC/MS	EPA 8270D	Dimethylphthalate
GC/MS	EPA 8270D	Di-n-butylphthalate
GC/MS	EPA 8270D	Di-n-octylphthalate
GC/MS	EPA 8270D	Fluoranthene
GC/MS	EPA 8270D	Fluorene
GC/MS	EPA 8270D	Hexachlorobenzene
GC/MS	EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270D	Hexachloroethane





and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8270D	Indeno(1,2,3-c,d)pyrene
GC/MS	EPA 8270D	Isop <mark>ho</mark> rone
GC/MS	EPA 8270D	m+p-Cresol
GC/MS	EPA 8270D	Naphthalene Naphthalene
GC/MS	EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	N-Nitrosodimethylamine
GC/MS	EPA 8270D	n-Nitroso-di-n-propylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270D	N-Nitrosopyrrolidine
GC/MS	EPA 8270D	o-Cresol
GC/MS	EPA 8270D	Pentachlorophenol
GC/MS	EPA 8270D	Phenanthrene Phenanthrene
GC/MS	EPA 8270D	Phenol
GC/MS	EPA 8270D	Pyrene
GC/MS	EPA 8270D	Pyridine
GC/MS	EPA 8270D SIM	Acenaphthene
GC/MS	EPA 8270D SIM	Acenaphthylene
GC/MS	EPA 8270D SIM	Anthracene
GC/MS	EPA 8270D SIM	Benzo(a)anthracene
GC/MS	EPA 8270D SIM	Benzo(a)pyrene
GC/MS	EPA 8270D SIM	Benzo(b)fluoranthene
GC/MS	EPA 8270D SIM	Benzo(g,h,i)perylene
GC/MS	EPA 8270D SIM	Benzo(k)fluoranthene
GC/MS	EPA 8270D SIM	Chrysene
GC/MS	EPA 8270D SIM	Dibenz(a,h)anthracene
GC/MS	EPA 8270D SIM	1,4-Dioxane
GC/MS	EPA 8270D SIM	Fluoranthene
GC/MS	EPA 8270D SIM	Fluorene
GC/MS	EPA 8270D SIM	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D SIM	1-Methylphenol
GC/MS	EPA 8270D SIM	2-Methylphenol
GC/MS	EPA 8270D SIM	Naphthalene
GC/MS	EPA 8270D SIM	Pentachlorophenol
GC/MS	EPA 8270D SIM	Phenanthrene
GC/MS	EPA 8270D SIM	Pyrene
GC/MS	EPA 8260B	1,1,1,2-Tetrachloroethane





and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8260B	1,1,1-Trichloroethane
GC/MS	EPA 8260B	1,1, <mark>2,2</mark> -Tetrachloroethene
GC/MS	EPA 8260B	1,1, <mark>2-Tr</mark> ichloroethane
GC/MS	EPA 8260B	1,1-Dichloroethane
GC/MS	EPA 8260B	1,1-Dichloroethene
GC/MS	EPA 8260B	1,1-Dichloropropene
GC/MS	EPA 8260B	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B	1,2,3-Trichloropropane
GC/MS	EPA 8260B	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B	1,2-Dibromo-3-chloropropane
GC/MS	EPA 8260B	1,2-Dibromoethane (EDB)
GC/MS	EPA 8260B	1,2-Dichlorobenzene
GC/MS	EPA 8260B	1,2-Dichloroethane
GC/MS	EPA 8260B	1,2-Dichloropropane
GC/MS	EPA 8260B	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B	1,3-Dichlorobenzene
GC/MS	EPA 8260B	1,3-Dichloropropane
GC/MS	EPA 8260B	1,4-Dichlorobenzene
GC/MS	EPA 8260B	1,4-Dioxane
GC/MS	EPA 8260B	2,2-Dichloropropane
GC/MS	EPA 8260B	2-Butanone (MEK)
GC/MS	EPA 8260B	2-Chloroethylvinyl ether
GC/MS	EPA 8260B	2-Chlorotoluene
GC/MS	EPA 8260B	2-Hexanone
GC/MS	EPA 8260B	4-Chlorotoluene
GC/MS	EPA 8260B	4-Methyl-2-pentanone
GC/MS	EPA 8260B	Acetone
GC/MS	EPA 8260B	Acetonitrile
GC/MS	EPA 8260B	Acrolein
GC/MS	EPA 8260B	Acrylonitrile
GC/MS	EPA 8260B	Allyl chloride
GC/MS	EPA 8260B	Benzene
GC/MS	EPA 8260B	Benzyl chloride
GC/MS	EPA 8260B	Bromobenzene
GC/MS	EPA 8260B	Bromochloromethane





and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8260B	Bromodichloromethane
GC/MS	EPA 8260B	Bro <mark>mo</mark> form
GC/MS	EPA 8260B	Bromethane
GC/MS	EPA 8260B	Carbon disulfide
GC/MS	EPA 8260B	Carbon tetrachloride
GC/MS	EPA 8260B	Chlorobenzene
GC/MS	EPA 8260B	Chloroethane
GC/MS	EPA 8260B	Chloroform
GC/MS	EPA 8260B	Chloromethane
GC/MS	EPA 8260B	Chloroprene
GC/MS	EPA 8260B	cis-1,2-Dichloroethene
GC/MS	EPA 8260B	cis-1,3-Dichloropropene
GC/MS	EPA 8260B	Cyclohexane
GC/MS	EPA 8260B	Cyclohexanone
GC/MS	EPA 8260B	Dibromochloromethane
GC/MS	EPA 8260B	Dibromomethane
GC/MS	EPA 8260B	Dichlorodifluoromethane
GC/MS	EPA 8260B	Diisopropyl ether (IPE)
GC/MS	EPA 8260B	Ethyl ether
GC/MS	EPA 8260B	Ethyl methacrylate
GC/MS	EPA 8260B	Ethylbenzene
GC/MS	EPA 8260B	Freon 113
GC/MS	EPA 8260B	Hexachlorobutadiene
GC/MS	EPA 8260B	Isobutyl alcohol
GC/MS	EPA 8260B	Isopropylbenzene
GC/MS	EPA 8260B	m+p-Xylenes
GC/MS	EPA 8260B	Methacrylonitrile
GC/MS	EPA 8260B	Methyl Acetate
GC/MS	EPA 8260B	Methyl iodide
GC/MS	EPA 8260B	Methyl methacrylate
GC/MS	EPA 8260B	Methyl tertiary butyl ether (MTBE)
GC/MS	EPA 8260B	Methylcyclohexane
GC/MS	EPA 8260B	Methylene chloride
GC/MS	EPA 8260B	Naphthalene
GC/MS	EPA 8260B	n-Butylbenzene
GC/MS	EPA 8260B	n-Propylbenzene





and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8260B	o-Xy <mark>l</mark> ene
GC/MS	EPA 8260B	Pentachloroethane
GC/MS	EPA 8260B	p-Is <mark>opro</mark> pyltoluene
GC/MS	EPA 8260B	Pro <mark>pioni</mark> trile
GC/MS	EPA 8260B	sec-Butylbenzene
GC/MS	EPA 8260B	Styrene
GC/MS	EPA 8260B	tert-Butylbenzene
GC/MS	EPA 8260B	Tetrachloroethene
GC/MS	EPA 8260B	Tetrahydrofuran
GC/MS	EPA 8260B	Toluene
GC/MS	EPA 8260B	Total Xylenes
GC/MS	EPA 8260B	trans-1,2-Dichloroethene
GC/MS	EPA 8260B	trans-1,3-Dichloropropene
GC/MS	EPA 8260B	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B	Trichloroethene
GC/MS	EPA 8260B	Trichlorofluoromethane
GC/MS	EPA 8260B	Vinyl acetate
GC/MS	EPA 8260B	Vinyl chloride
GC/MS	EPA 8260B SIM	1,4-Dioxane
GC	EPA 8081B	4,4'-DDD
GC	EPA 8081B	4,4'-DDE
GC	EPA 8081B	4,4'-DDT
GC	EPA 8081B	Aldrin
GC	EPA 8081B	alpha-BHC
GC	EPA 8081B	alpha-Chlordane
GC	EPA 8081B	beta-BHC
GC	EPA 8081B	Chlordane
GC	EPA 8081B	delta-BHC
GC	EPA 8081B	Dieldrin
GC	EPA 8081B	Endosulfan I
GC	EPA 8081B	Endosulfan II
GC	EPA 8081B	Endosulfan sulfate
GC	EPA 8081B	Endrin
GC	EPA 8081B	Endrin Aldehyde
GC	EPA 8081B	Endrin Ketone
GC	EPA 8081B	gamma-BHC (Lindane)





Solid and Chemical Materials		
Technology	Method	Analyte
GC	EPA 8081B	gam <mark>m</mark> a-Chlordane
GC	EPA 8081B	Hep <mark>tac</mark> hlor
GC	EPA 8081B	Heptachlor Epoxide
GC	EPA 8081B	Methoxychlor
GC	EPA 8081B	Mirex
GC	EPA 8081B	Toxaphene
GC	EPA 8082A	Aroclor 1016
GC	EPA 8082A	Aroclor 1221
GC	EPA 8082A	Aroclor 1232
GC	EPA 8082A	Aroclor 1242
GC	EPA 8082A	Aroclor 1248
GC	EPA 8082A	Aroclor 1254
GC	EPA 8082A	Aroclor 1260
GC	EPA 8082A	Aroclor 1262
GC	EPA 8082A	Aroclor 1268
HPLC	EPA 8330A	2-Amino-4,6-dinitrotoluene
HPLC	EPA 8330A	4-Amino-2,6-dinitrotoluene
HPLC	EPA 8330A	1,3-Dinitrobenzene
HPLC	EPA 8330A	2,4-Dinitrotoluene
HPLC	EPA 8330A	2,6-Dinitrotoluene
HPLC	EPA 8330A	HMX
HPLC	EPA 8330A	Nitrobenzene
HPLC	EPA 8330A	2-Nitrotoluene
HPLC	EPA 8330A	3-Nitrotoluene
HPLC	EPA 8330A	4-Nitrotoluene
HPLC	EPA 8330A	RDX
HPLC	EPA 8330A	Tetryl
HPLC	EPA 8330A	1,3,5-Trinitrobenzene
HPLC	EPA 8330A	2,4,6-Trinitrotoluene
GC	EPA 8015C	Diesel Range Organics
GC	EPA 8015C	WI-Diesel Range Organics
GC	EPA 8015C	Gasoline Range Organics
GC	EPA 8015C	WI-Gasoline Range Organics
GC	FL-PRO	FL-PRO





Solid and Chemical Materials			
Technology	Method	Analyte	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Fluorotelomer sulfonate 8:2 [1H,1H,2H,2H-perfluorodecane sulfonate] (8:2 FTS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Fluorotelomer sulfonate 4:2 [1H,1H,2H,2H-perfluorohexane sulfonate] (4:2 FTS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Fluorotelomer sulfonate 6:2 [1H,1H,2H,2H-perfluorooctane sulfonate] (6:2 FTS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	GenX (HFPO-DA)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-butanesulfonate (PFBS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-butanoic acid (PFBA)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-decanesulfonate (PFDS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-decanoic acid (PFDA)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-dodecanoic acid (PFDoA)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-heptanesulfonate (PFHpS)	
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-heptanoic acid (PFHpA)	





Solid and Chemical Materials		
Technology	Method	Analyte
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-hexanesulfonate (PFHxS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-hexanoic acid (PFHxA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-nonanesulfonate (PFNS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-nonanoic acid (PFNA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctanesulfonate (PFOS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-octanesulfonamide (PFOSA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-octanoic acid (PFOA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-pentanoic acid (PFPeA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-1-pentansulfonate (PFPeS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-tetradecanoic acid (PFTeDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-tridecanoic acid (PFTrDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoro-n-undecanoic acid (PFUDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-methylperfluoro-1-octanesulfonamide (MeFOSA)





Solid and Chemical Materials		
Technology	Method	Analyte
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-ethylperfluoro-1-octanesulfonamide (EtFOSA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	1H,1H,2H,2H-perfluorododecane sulfonate (10:2FTS)
HPLC	EPA 8330B MOD	2-Amino-4,6-dinitrotoluene
HPLC	EPA 8330B MOD	4-Amino-2,6-dinitrotoluene
HPLC	EPA 8330B MOD	1,3-Dinitrobenzene
HPLC	EPA 8330B MOD	2,4-Dinitrotoluene
HPLC	EPA 8330B MOD	2,6-Dinitrotoluene
HPLC	EPA 8330B MOD	HMX
HPLC	EPA 8330B MOD	Nitrobenzene
HPLC	EPA 8330B MOD	Nitroglycerin (NG)
HPLC	EPA 8330B MOD	2-Nitrotoluene
HPLC	EPA 8330B MOD	3-Nitrotoluene
HPLC	EPA 8330B MOD	4-Nitrotoluene
HPLC	EPA 8330B MOD	RDX
HPLC	EPA 8330B MOD	Tetryl
HPLC	EPA 8330B MOD	1,3,5-Trinitrobenzene
HPLC	EPA 8330B MOD	2,4,6-Trinitrotoluene
ICP	EPA 6010D	Copper
ICP	EPA 6010D	Iron
ICP	EPA 6010D	Lead
ICP	EPA 6010D	Magnesium
ICP	EPA 6010D	Manganese
ICP	EPA 6010D	Molybdenum
ICP	EPA 6010D	Nickel
ICP	EPA 6010D	Potassium
ICP	EPA 6010D	Selenium
ICP	EPA 6010D	Silver
ICP	EPA 6010D	Sodium
ICP	EPA 6010D	Thallium
ICP	EPA 6010D	Tin
ICP	EPA 6010D	Vanadium
ICP	EPA 6010D	Zinc
ICP/MS	EPA 6020B	Aluminum

III ANAE



and Chemical Materials		
Technology	Method	Analyte
ICP/MS	EPA 6020B	Antimony
ICP/MS	EPA 6020B	Arsenic
ICP/MS	EPA 6020B	Barium
ICP/MS	EPA 6020B	Beryllium
ICP/MS	EPA 6020B	Cadmium
ICP/MS	EPA 6020B	Calcium
ICP/MS	EPA 6020B	Chromium
ICP/MS	EPA 6020B	Cobalt
ICP/MS	EPA 6020B	Copper
ICP/MS	EPA 6020B	Iron
ICP/MS	EPA 6020B	Lead
ICP/MS	EPA 6020B	Magnesium
ICP/MS	EPA 6020B	Manganese
ICP/MS	EPA 6020B	Nickel
ICP/MS	EPA 6020B	Potassium
ICP/MS	EPA 6020B	Selenium
ICP/MS	EPA 6020B	Silver
ICP/MS	EPA 6020B	Sodium
ICP/MS	EPA 6020B	Thallium
ICP/MS	EPA 6020B	Vanadium
ICP/MS	EPA 6020B	Zinc
CVAA	EPA 7471B	Mercury
Titration	Walkley-Black	TOC
UV/VIS	EPA 9012B	Total Cyanide
UV/VIS	EPA 9065	Phenolics
UV/VIS	EPA 9066	Phenolics
IC	EPA 9056A	Bromide
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Sulfate
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 300.0	Fluoride
IC	EPA 300.0	Chloride
IC	EPA 300.0	Sulfate
IC	EPA 300.0	Bromide

ANAB



Solid and Chemical Materials			
Technology	Method	Analyte	
IC	EPA 300.0	Nitrate	
IC	EPA 300.0	Nitrite	
IC	EPA 7199 / EPA 3060A	Hexavalent chromium	
UV/VIS	EPA 7196A EPA 3060A	Hexavalent chromium	
Pensky-Martens	EPA 1010A	Ignitabili ty	
Electrode	EPA 9045D	Corrosivity	
Titration	Sec. 7.3.3 SW-846	Reactive Cyanide	
Photometric	Sec. 7.3.4 SW-846	Reactive Sulfide	
Filtration	EPA 9095B	Paint Filter Test	
UV/VIS	EPA 365.1 MOD	Phosphorus	
UV/VIS	EPA 353.2 MOD	Nitrate	
UV/VIS	EPA 353.2 MOD	Nitrite	
UV/VIS	EPA 353.2 MOD	Nitrate-Nitrite	
UV/VIS	EPA 350.1	Ammonia	
Gas Diffusion / UV/VIS	EPA 350.1	Ammonia - N	
UV/VIS	EPA 351.2 MOD	TKN	
GC	MADEP-EPH MOD	Extractable Petroleum Hydrocarbons (EPH) Modified	
GC	MADEP-VPH-MOD	Volatile Petroleum Hydrocarbons (VPH) Modified	
Preparation	Method	Type	
Organic Preparation	EPA 3550C	Preparation of Soil by Sonication	
Organic Preparation	EPA 3546	Microwave Extraction	
Organic Cleanup	EPA 3620B	Florisil Cleanup Procedure	
Organic Cleanup	EPA 3660B	Sulfur Cleanup Procedure	
Organic Cleanup	EPA 3665A	Sulfuric Acid Cleanup Procedure	
Organic Cleanup	EPA 3640C	GPC Cleanup Procedure	
Volatile Organic Preparation	EPA 5035	Closed-System Purge-and-Trap and extraction for Volatile Organics in Soil and Waste Samples	
Volatile Organic Preparation	EPA 3585	Waste Dilution for Volatile Organics	
Waste Dilution	EPA 3580A	Waste Dilution	
Inorganic Preparation	EPA 3050B	Preparation of Soils by Hotblock	
Inorganic Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure (TCLP)	
Inorganic Preparation	EPA 1312	Synthetic Precipitation Leaching Procedure (SPLP)	
Inorganic Metals Preparation	EPA 3010A	Acid Digestion of Aqueous Samples and TCLP/SPLP Extracts	

ANAB



Biological Tissue		
Technology	Method	Analyte
GC	EPA 8081B	4,4'-DDE
GC	EPA 8081B	4,4'-DDT
GC	EPA 8081B	Aldrin
GC	EPA 8081B	alpha-BHC
GC	EPA 8081B	alpha-Chlordane
GC	EPA 8081B	beta-BHC
GC	EPA 8081B	Chlordane
GC	EPA 8081B	delta-BHC
GC	EPA 8081B	Dieldrin
GC	EPA 8081B	Endosulfan I
GC	EPA 8081B	Endosulfan II
GC	EPA 8081B	Endosulfan sulfate
GC	EPA 8081B	Endrin
GC	EPA 8081B	Endrin Aldehyde
GC	EPA 8081B	Endrin Ketone
GC	EPA 8081B	gamma-BHC (Lindane)
GC	EPA 8081B	gamma-Chlordane
GC	EPA 8081B	Heptachlor
GC	EPA 8081B	Heptachlor Epoxide
GC	EPA 8081B	Methoxychlor
GC	EPA 8081B	Toxaphene
GC	EPA 8082A	Aroclor 1016
GC	EPA 8082A	Aroclor 1221
GC	EPA 8082A	Aroclor 1232
GC	EPA 8082A	Aroclor 1242
GC	EPA 8082A	Aroclor 1248
GC	EPA 8082A	Aroclor 1254
GC	EPA 8082A	Aroclor 1260
GC	EPA 8082A	Aroclor 1262
GC	EPA 8082A	Aroclor 1268
GC/MS	EPA 8270D	1,1'-Biphenyl
GC/MS	EPA 8270D	1-Methylnaphthalene
GC/MS	EPA 8270D	2-Methylnaphthalene
GC/MS	EPA 8270D	Acenaphthene
GC/MS	EPA 8270D	Acenaphthylene
GC/MS	EPA 8270D	Anthracene
GC/MS	EPA 8270D	Atrazine



Biological Tissue			
Technology	Method	Analyte	
GC/MS	EPA 8270D	Bronzo(a)anthracene	
GC/MS	EPA 8270D	Benzo(b)fluoranthene	
GC/MS	EPA 8270D	Benzo(g,h,i)perylene	
GC/MS	EPA 8270D	Benzo(k)fluoranthene	
GC/MS	EPA 8270D	Chrysene	
GC/MS	EPA 8270D	Dibenzo(a,h)anthracene	
GC/MS	EPA 8270D	Dibenzofuran	
GC/MS	EPA 8270D	Dimethoate	
GC/MS	EPA 8270D	Disulfoton	
GC/MS	EPA 8270D	Fluoranthene	
GC/MS	EPA 8270D	Fluorene	
GC/MS	EPA 8270D	Hexachlorobenzene	
GC/MS	EPA 8270D	Indeno(1,2,3-c,d)pyrene	
GC/MS	EPA 8270D	Methyl parathion	
GC/MS	EPA 8270D	Naphthalene	
GC/MS	EPA 8270D	Phenanthrene	
GC/MS	EPA 8270D	Phorate	
GC/MS	EPA 8270D	Pronamide	
GC/MS	EPA 8270D	Pyrene	
Preparation	Method	Туре	
Organic Preparation	EPA 3540C	Soxhlet Extraction	

Drinking water			
Technology	Method	Analyte	
GC/MS	EPA 524.2	1,1,1,2-Tetrachloroethane	
GC/MS	EPA 524.2	1,1,1-Trichloroethane	
GC/MS	EPA 524.2	1,1,2,2-Tetrachloroethane	
GC/MS	EPA 524.2	1,1,2-Trichloroethane	
GC/MS	EPA 524.2	1,1-Dichloroethane	
GC/MS	EPA 524.2	1,1-Dichloroethene	
GC/MS	EPA 524.2	1,1-Dichloropropene	
GC/MS	EPA 524.2	1,2,3-Trichlorobenzene	
GC/MS	EPA 524.2	1,2,3-Trichloropropane	
GC/MS	EPA 524.2	1,2,4-Trichlorobenzene	
GC/MS	EPA 524.2	1,2,4-Trimethylbenzene	





Drinking water		
Technology	Method	Analyte
GC/MS	EPA 524.2	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 524.2	1,2-Dibromoethane (EDB)
GC/MS	EPA 524.2	1,2-Dich <mark>loro</mark> benzene
GC/MS	EPA 524.2	1,2-Dic <mark>hloro</mark> ethane
GC/MS	EPA 524.2	1,2-Di <mark>chloro</mark> propane
GC/MS	EPA 524.2	1,3,5-Trimethylbenzene
GC/MS	EPA 524.2	1,3-Dichlorobenzene
GC/MS	EPA 524.2	1,3-Dichloropropane
GC/MS	EPA 524.2	1,4-Dichlorobenzene
GC/MS	EPA 524.2	2,2-Dichloropropane
GC/MS	EPA 524.2	2-Butanone (MEK)
GC/MS	EPA 524.2	2-Chlorotoluene
GC/MS	EPA 524.2	2-Hexanone
GC/MS	EPA 524.2	2-Nitropropane
GC/MS	EPA 524.2	3-Chloropropene (Allyl chloride)
GC/MS	EPA 524.2	4-Chlorotoluene
GC/MS	EPA 524.2	4-Methyl-2-pentanone
GC/MS	EPA 524.2	Acetone
GC/MS	EPA 524.2	Acrylonitrile
GC/MS	EPA 524.2	Benzene
GC/MS	EPA 524.2	Bromobenzene
GC/MS	EPA 524.2	Bromochloromethane
GC/MS	EPA 524.2	Bromodichloromethane
GC/MS	EPA 524.2	Bromoform
GC/MS	EPA 524.2	Bromomethane (Methyl bromide)
GC/MS	EPA 524.2	Carbon disulfide
GC/MS	EPA 524.2	Carbon tetrachloride
GC/MS	EPA 524.2	Chlorobenzene
GC/MS	EPA 524.2	Chloroethane
GC/MS	EPA 524.2	Chloroform
GC/MS	EPA 524.2	Chloromethane (Methyl chloride)
GC/MS	EPA 524.2	cis-1,2-Dichloroethene
GC/MS	EPA 524.2	cis-1,3-Dichloropropene
GC/MS	EPA 524.2	Cyclohexane
GC/MS	EPA 524.2	Dibromochloromethane
GC/MS	EPA 524.2	Dibromomethane (Methylene bromide)

IIIC MRA ANAB



ing water		
Technology	Method	Analyte
GC/MS	EPA 524.2	Dichlorodifluoromethane
GC/MS	EPA 524.2	Ethyl ether
GC/MS	EPA 524.2	Ethyl methacrylate
GC/MS	EPA 524.2	Ethylbenzene
GC/MS	EPA 524.2	Hexachlorobutadiene
GC/MS	EPA 524.2	Isopropylbenzene
GC/MS	EPA 524.2	m+p - Xylenes
GC/MS	EPA 524.2	Methacrylonitrile
GC/MS	EPA 524.2	Methyl iodide (Iodomethane)
GC/MS	EPA 524.2	Methyl methacrylate
GC/MS	EPA 524.2	Methyl tertiary butyl ether (MTBE)
GC/MS	EPA 524.2	Methylene chloride
GC/MS	EPA 524.2	Naphthalene
GC/MS	EPA 524.2	n-Butylbenzene
GC/MS	EPA 524.2	n-Propylbenzene
GC/MS	EPA 524.2	o - Xylenes
GC/MS	EPA 524.2	Pentachloroethane
GC/MS	EPA 524.2	p-Isopropyltoluene
GC/MS	EPA 524.2	Propionitrile (Ethyl cyanide)
GC/MS	EPA 524.2	sec-Butylbenzene
GC/MS	EPA 524.2	Styrene
GC/MS	EPA 524.2	tert-Butylbenzene
GC/MS	EPA 524.2	Tetrachloroethene
GC/MS	EPA 524.2	Toluene
GC/MS	EPA 524.2	trans-1,2-Dichloroethene
GC/MS	EPA 524.2	trans-1,3-Dichloropropene
GC/MS	EPA 524.2	trans-1,4-Dichloro-2-butene
GC/MS	EPA 524.2	Trichloroethene
GC/MS	EPA 524.2	Trichlorofluoromethane
GC/MS	EPA 524.2	Vinyl chloride
GC/MS	EPA 524.2	Xylenes (total)
LC/MS/MS	EPA 537	N-ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)
LC/MS/MS	EPA 537	N-methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)
LC/MS/MS	EPA 537	Perfluoro-1-butanesulfonate (PFBS)

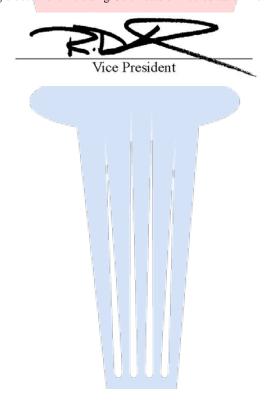


Drinking water		
Technology	Method	Analyte
LC/MS/MS	EPA 537	Perfluoro-n-decanoic acid (PFDA)
LC/MS/MS	EPA 537	Perfluoro-n-dodecanoic acid (PFDoA)
LC/MS/MS	EPA 537	Perfluoro-n-heptanoic acid (PFHpA)
LC/MS/MS	EPA 537	Perfluoro-1-hexanesulfonate (PFHxS)
LC/MS/MS	EPA 537	Perfluoro-n-hexanoic acid (PFHxA)
LC/MS/MS	EPA 537	Perfluoro-n-nonanoic acid (PFNA)
LC/MS/MS	EPA 537	Perfluorooctanesulfonate (PFOS)
LC/MS/MS	EPA 537	Perfluoro-n-octanoic acid (PFOA)
LC/MS/MS	EPA 537	Perfluoro-n-tetradecanoic acid (PFTeDA)
LC/MS/MS	EPA 537	Perfluoro-n-tridecanoic acid (PFTrDA)
LC/MS/MS	EPA 537	Perfluoro-n-undecanoic acid (PFUDA)

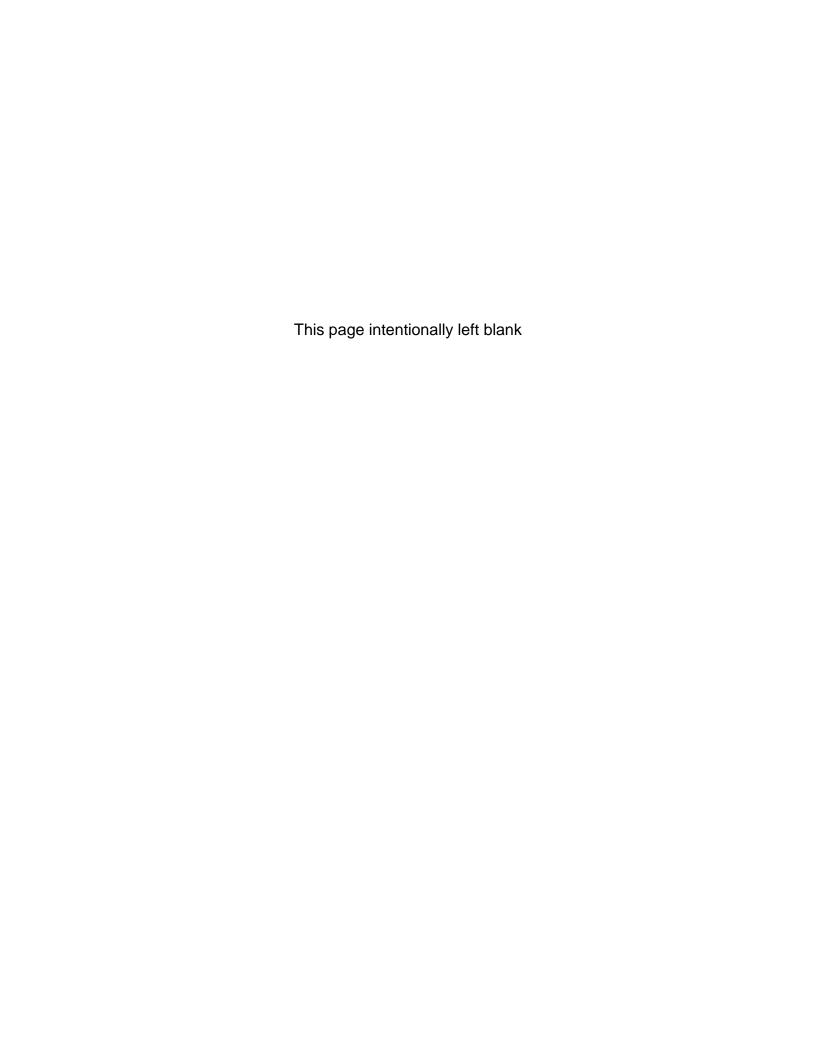
Note:

Version: 007 Issued: October 17, 2018

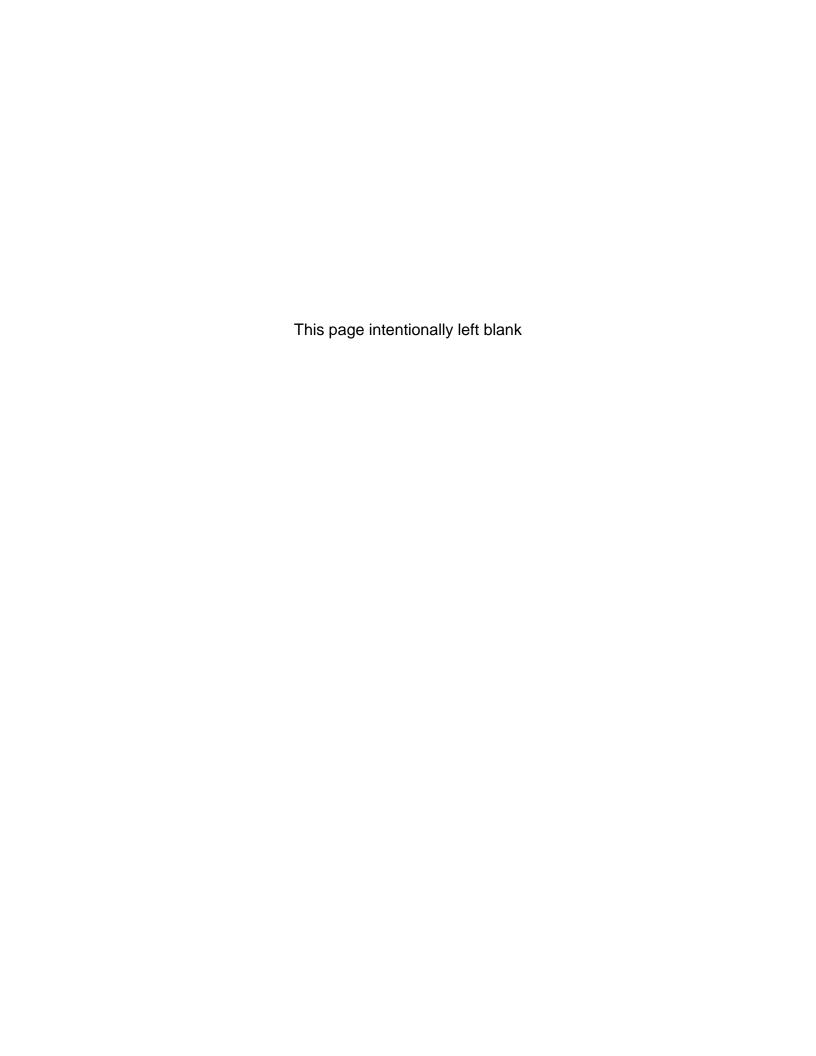
1. This scope is formatted as part of a single document including Certificate of Accreditation No. L2224.







APPENDIX D LABORATORY SOPs



Page 1 of 100 Effective Date: 7/13/2018

ENVIRONMENTAL QUANTITATION INCORPORATED

formerly Shealy Environmental Services, Inc.

Quality Assurance Management Plan (QAMP)

7/4/2018 1:48:21 PM Daniel J. Wright

Daniel Wright

Robert She

Laboratory Director

7/5/2018 9:14:28 AM

Robert Zhu

Technical Director

Wardy Plesing

7/6/2018 1:13:37 PM Wendy Plessinger

Quality Assurance Officer

Bradle Billi

7/5/2018 7:37:53 AM

Bradley E. Belding Operations Director

Proprietary Information Statement:

This document has been prepared by and remains the sole property of Shealy Environmental Services, Inc. It is submitted to a client or government agency solely for its use in evaluating Shealy's qualifications in connection with the particular project, certification, or approval for which it was prepared. This document is to be held proprietary to Shealy.

The user agrees by its acceptance or use of this document to return it upon Shealy's request and to not reproduce, copy, lend, or otherwise disclose or dispose of the contents, directly or indirectly. The user also agrees to not use it for any purpose other than that for which it was specifically furnished. The user agrees that access to this document shall not be given to consultants or others outside of the user's organization when those parties are involved in the evaluation process, unless those parties also specifically agree to these conditions.

Page 2 of 100 Effective Date: 7/13/2018

TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1.	Overview, Mission, Vision, Values	5
2.	MANAGEMENT AND ORGANIZATION	7
2.1.	Statement of Management Commitment to Quality	7
2.2.	Approved Signatories	7
2.3.	Quality Organizational Structure	8
2.4.	Quality Management System	18
2.5.	Quality System Components	19
2.6.	Implementation	20
3.	PERSONNEL QUALIFICATIONS AND TRAINING	20
3.1.	Personnel Qualifications	20
3.2.	Personnel Training	23
3.3.	Ongoing Training	26
3.4.	Quality Assurance Officer Training	26
3.5.	Training Files	26
4.	PROCUREMENT OF LABORATORY MATERIALS AND SERVICES	26
5.	DOCUMENTS AND RECORDS	27
5.1.	QAMP, SOPs and Policies	27
5.2.	Establishment and Review of Forms and Spreadsheets	29
5.3.	Control and Distribution of the QAMP, SOPs, Policies, Forms and Spreadsheets	29
5.4.	Analytical Logbooks	29
5.5.	Quality and Project Records Management	29
5.6.	Data Confidentiality	30

6.	COMPUTER HARDWARE AND SOFTWARE	30
6.1.	Laboratory Information Management System (LIMS / EQLIMS)	31
6.2.	Target, AIM and MARRS	33
6.3.	Industry Standard Software	34
6.4.	Hardware	34
6.5.	Training	35
7.	PROJECT PLANNING AND CONTROL	35
7.1.	Assignment of a Project Manager	36
7.2.	Quote / Proposal Generation	36
7.3.	Quote / Proposal Review	36
7.4.	Detailed Project Planning	36
7.5.	Contingency Planning	37
8.	EQI OPERATIONS	38
8.1.	Physical Facility	38
8.2.	Laboratory Areas	39
8.3.	Equipment and Services	43
8.4.	Sample Processing	45
8.5.	Sustainability	54
9.	QUALITY SYSTEMS	56
9.1.	Data Quality Objectives	56
9.2.	Quality Control	59
9.3.	Calibration of Equipment	64
9.4.	Uncertainty Measurements for Results	65
9.5.	Standards and Reagents	66
9.6.	Data Recording	67

Shealy Environmental Services, Inc.

Page 4 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.7.	Data Review	68
9.7.4.	Data Package Review (Level IV Review) (where applicable)	71
9.8.	Data Evaluation and Corrective Action	71
9.9.	Reporting of Data	83
10.	QUALITY ASSESSMENT AND IMPROVEMENT	84
10.1.	Nonconformance Events	84
10.2.	Quality Assessment Audits	86
10.3.	Management Review	87
10.4.	Client Complaints	88
10.5.	Client Surveys	88
11.	REFERENCES	88
APPI	ENDIX A: SYNOPSES OF KEY TECHNICAL STAFF	90
ADD	ENDUM TO THE QUALITY ASSURANCE MANAGEMENT PLAN	100

Shealy Environmental Services, Inc. Document Number: ME0012K-06

Page 5 of 100 Effective Date: 7/13/2018

1. Introduction

The Environmental Quantitation Incorporated ("EQI") Quality Assurance Management Plan (QAMP) has been written to provide guidance and direction to all EQI employees regarding quality assurance. The QAMP defines and documents all quality related activities, policies, programs, responsibilities, and controls required to provide legally defensible data.

This QAMP refers to other EQI documents, including those that describe general policy, give guidance and instruction, and the standard operating procedures (SOPs). Together, all these documents comprise the written basis of the EQI Quality Management System (QMS).

Our clients and various regulatory/certification agencies require documentation of our QMS. This QAMP fulfills a large part, but not all of this requirement. The project-specific requirements delineated in project plans may supersede the general quality requirements described in this document.

Additionally, this document addresses the basic information required for a quality management plan as described by the ISO17025 accreditation, the United States Environmental Protection Agency (USEPA), the National Environmental Laboratory Accreditation Program (NELAP), and the Department of Defense (DoD) and Department of Energy (DOE) Quality Systems Manual (QSM).

1.1. Overview, Mission, Vision, Values

1.1.1. Overview

EQI is classified as a small business, incorporated in the State of South Carolina, providing services covered under NAICS code 541380. EQI currently holds laboratory certifications through the South Carolina Department of Health and Environmental Control, the North Carolina Department of Environmental Quality, the Delaware Office of Drinking Water, and the Kentucky Division of Waste Management Underground Storage Tank Division. EQI holds Department of Defense (DoD) and ISO 17025 accreditation, primary National Environmental Laboratory Accreditation Program (NELAP) certification through the state of Florida Department of Health, Bureau of Laboratories as well as secondary accreditations with the Kentucky Department of Environmental Protection, the Commonwealth of Virginia, the Kansas Department of Health & Environment and the Illinois Environmental Protection Agency. A list of current certifications is found in the addendum to this document.

EQI was founded in 1982 (as Shealy Environmental Services, Incorporated) with the vision of establishing a full-service environmental laboratory. With the aid of a small mobile laboratory, our initial services were primarily biological in nature. Since that beginning, EQI has prudently expanded its operation to provide unequaled services to a steadily growing clientele in the private and governmental business sectors. In 1985, a permanent laboratory was established in Columbia, South Carolina, to meet expanded service needs. In 1987, an analytical laboratory was added providing organic, inorganic, and microbiological analyses. In 1992, the entire business was moved to a facility that was custom- designed and constructed specifically as an environmental laboratory.

Shealy Environmental Services, Inc.

Page 6 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

EQI management has consistently utilized responsible business practices, allowing the company to experience healthy growth while many other environmental testing laboratories were collapsing. We continuously invest in new instrumentation, software, computer systems, and experienced scientists to remain current with the latest technology and maintain the ability to provide the best service and highest quality data possible to our clients.

In 2001, EQI was among the first round of laboratories to earn accreditation by The National Environmental Laboratory Accreditation Conference Institute (NELAC or TNI). TNI's vision is to foster a national accreditation program, where environmental laboratories within the United States are accredited to one uniform, rigorous, and robust program (National Environmental Laboratory Accreditation Program (NELAP). In 2013, the company was purchased by the current owners and in 2017, the name was changed to Environmental Quantitation Incorporated.

EQI has been in the US EPA Contract Laboratory Program (CLP) since 2001. We have active CLP contracts for the analysis of multi-media, multi-concentration organic, metals, and inorganic non-metals compounds in water and solid samples by SOM02.4 and ISM02.4 methodologies. To become part of the CLP, laboratories must meet stringent requirements and standards for equipment, personnel, laboratory practices, and analytical and quality control (QC) operations.

The Department of Defense (DoD) Environmental Data Quality Workgroup (EDQW) and the Department of Energy (DOE) Consolidated Audit Program (DOECAP) Operations Team developed the DoD/DOE Quality Systems Manual (QSM) for Environmental Laboratories. The QSM is a set of requirements based upon the TNI requirements and ISO17025 for establishing and managing quality systems for laboratories performing analytical testing services for the DoD and the DOE. Conformance to the requirements is mandatory for any laboratory that is maintaining accreditation in accordance with the DoD Environmental Laboratory Accreditation Program (ELAP) or maintaining qualification in accordance with the DOECAP and DOE related contract awards. As a result of all these efforts and accomplishments, EQI has achieved its vision of becoming a reliable, full-service, and high-quality environmental laboratory. EQI is recognized as a responsive and credible environmental laboratory focused on creating cost- effective and workable solutions to meet individual client needs.

1.1.2. Mission

EQI exists to provide accurate, legally defensible data in the requested deliverables to industries, municipalities, consulting/engineering firms, and government agencies within the timeframes required.

1.1.3. Statement of Vision

EQI's vision is to be recognized regionally and nationally as an innovative, client-focused, high quality, on time, environmental laboratory that supports diverse regulatory programs.

EQI's focus is client satisfaction, quality, and sound science.

Shealy Environmental Services, Inc.

Page 7 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

1.1.4. Values

Scientific knowledge, experience, integrity, trust, teamwork, and dedication to strong client relationships are the hallmarks of how EQI builds and maintains its reputation in the industry. By ensuring high professional standards and an open and responsive culture, we strive to provide the following to our staff and clients:

- Our staff deserve a safe workplace, fairness, respect, clear expectations, training, tools for high caliber performance, clear opportunities for career development and an environment that embraces teamwork, communication, & empowerment.
- Our clients deserve frequent and effective communication, high quality work compliant to our SOPs, QAMP, and applicable QAPP/SAPs, on-time deliverables, the highest integrity, and an excellent value.

2. Management and Organization

2.1. Statement of Management Commitment to Quality

EQI management is committed to providing services of unmatched quality that meet the technical and management objectives of our clients, while satisfying all applicable regulatory requirements. We strive to provide a working environment in our well-equipped state-of-the-art laboratory that encourages safety and excellence in all our activities, requires the participation of all employees in our quality efforts, and demands integrity from all employees. Providing on-going documented training both internally and externally facilitates this commitment.

The EQI QAMP provides the foundation for the overall quality level of our operation. It provides guidance to all employees in order for them to fulfill their job responsibilities, while serving as a statement of quality commitment to our clients and regulatory agencies.

EQI management is committed to compliance with the TNI standard, the Department of Defense Department of Energy (DOE) Consolidated Quality Systems Management Plan (DoD/DOE QSM), the USEPA Contract Laboratory Program (CLP) Statement of Work (SOW) and all applicable state and regulatory requirements. In addition, top management ensures that the integrity of the QMS is maintained when changes are made.

2.2. Approved Signatories

The following positions have the authority to sign off (give approval) on all documents used for business purposes or the operation of the laboratory:

Laboratory Director & Technical Director

The following positions have the authority to sign off (give approval) of any documents used for training and/or for the generation of data within their areas of expertise:

Shealy Environmental Services, Inc.

Page 8 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Operations Director
Quality Assurance Officer
Environmental Health and Safety Officer / Waste Manager / Radiation Safety Officer
Analytical Manager
Project Manager
Group Leaders
Sample Custodian
Analyst
IT Specialist

The following positions have the authority to include an electronic signature on either client reports, SOPs/Policies/QAMP and/or any other applicable documents within their areas of expertise:

Laboratory Director
Technical Director
Operations Director
Quality Assurance Officer
Analytical Manager
Quality Assurance Specialist
Quality Assurance Associate
Project Manager
Group Leaders

Electronic signatures are stored in LIMS and in EQLIMS and are populated in client reports, SOPs, Policies and the QAMP automatically upon approval.

2.3. Quality Organizational Structure

The achievement of the EQI vision is only possible through the implementation and on-going utilization of the EQI QAMP. The responsibility for this vision resides in the efforts of all employees as led by the management team. The following section describes the quality activities for various positions within the EQI organization.

The responsibilities and authority of the personnel holding these positions, as related to quality and the implementation of this QAMP, are described the sections below. The management structure and the overall organizational structure are presented in an addendum to this document which is subject to change [Management Organizational Chart (ME00185); Organizational Chart (ME0013A)].

2.3.1. President / CEO / Laboratory Director

- Responsible for the overall corporate philosophy and policy for quality.
- Responsible for ensuring the implementation of an effective quality system.
- Provides support and resources to implement all quality efforts and the EQI QAMP.
- Responsible for overall approval of the EQI QAMP.
- Responsible for management assessments.

Shealy Environmental Services, Inc.

Page 9 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Responsible for the financial oversight and management of the company.
- Responsible for the overall quality and production activities of the analytical laboratory.
- Responsible for the oversight of health and safety, facility, and human resources related matters.
- Ensures that an effective Comprehensive Chemical Hygiene, Safety, and Hazard Communication Plan and associated, documented training processes are in place.
- Approves the QAMP, SOPs, and other quality system documents.
- Assists with and supports all QA activities.
- Directs the overall laboratory operations to meet current and future client needs.
- Contributes to, develops, and focuses the quality assurance department on targeted market segments.
- Provides technical support on method development, automation, instrument performance, and production efficiency.
- Prioritizes IT projects to ensure that EQI has the necessary infrastructure to maintain a competitive advantage with respect to efficiency, reporting, and quality.
- Initiates improvements in operations and quality programs.
- Assigns specific personnel responsibilities and provides the overall direction to the Group Leaders and the Technical Director to improve quality and production related matters.
- Ensures that adequate staffing is available to perform the sample workload within the QMS framework.
- Ensures compliance with the TNI standard and the DoD QSM

2.3.2. Technical Director

- Reports directly to the Laboratory Director on all quality and operational matters.
- Approves the QAMP, SOPs, and other quality system documents.
- Responsible for the overall current use of technology in the laboratory including instruments, computers, and LIMS.
- Evaluates available technology which will make operations more efficient and meet current and future client needs. Directs the efforts to implement this technology.
- Supports the QA department with respect to SOPs, MDLs, acceptance limits/control charts, internal audits, and LIMS interaction.
- Contributes to the continuous improvement of all operations.
- Provides technical and operational guidance to analysts and Group Leaders.
- Reviews quality activities performed as part of the analytical operation.
- Trains analysts and ensures performance standards are achieved and documented.
- Provides technical support and instrument troubleshooting.
- Implements and oversees data review procedures.
- Supervises the preparation and maintenance of laboratory records.
- Ensures compliance with the TNI standard and the DoD QSM
- Oversees EPA CLP contracts
- Deputy to the Laboratory Director
- Data Integrity Officer
 - Facilitates anonymous reporting of data integrity issues / ethical violations
 - Maintains confidentiality for employees who wish to remain anonymous.
- Alternate Radiation Safety Officer (Alternate RSO)

Shealy Environmental Services, Inc.

Page 10 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Assists Radiation Safety Officer will all duties
- Acts as the Radiation Safety Officer in the event the RSO is not available.

2.3.3. Quality Assurance Officer (QAO)

- The QAO reports directly and independently to the Laboratory Director on all quality-related matters.
- Approves the QAMP, SOPs, and other quality system documents.
- Interacts with the Laboratory Director, Technical Director, Operations Director, Analytical Manager, and department Group Leaders regarding quality related matters.
- Responsible for assessing the adequacy, utilization, and implementation of the QMS.
- Supervises the preparation, maintenance, and storage of laboratory records.
- Responsible for ensuring and improving overall quality within the laboratory operation.
- Has authority to suspend sample processing activities when QA requirements are not met.
- Assists clients concerning data quality issues.
- Investigates and approves laboratory NCMs.
- Monitors data quality objectives (DQOs) to verify the laboratory meets stated levels of performance.
- Oversees corrective and preventive actions (CAPAs) and tracks them to closure
- Oversees procurement from the quality perspective
- Administers Proficiency Testing (PT) program in accordance with the TNI standard, DoD, and state reporting requirements.
- Interacts with regulatory bodies in matters of certification and accreditation.
- Performs quality audits and reports results to the Laboratory Director and laboratory management.
- Maintains all controlled quality related documents.
- Assists in employee training.
- Tracks and coordinates responses to external audit findings.
- Responsible for approval of the EQI QAMP.
- Monitors customer feedback and/or data quality via the report revision form, client complaint form, and annual customer survey.
- Performs annual management review
- Approves and tracks employee demonstrations of capability (DOC)
- Ensures compliance with the TNI standard and the DoD QSM
- Tracks and manages the QAMP, contingency plan, SOP, and policy updates.

2.3.4. Operations Director

- Reports to the Laboratory Director on all quality and operational matters.
- Approves the QAMP, SOPs, and other quality system documents.
- Responsible for the daily operation of all organics and inorganics departments.
- Directly supervises all analysts in the technical, quality, and operational aspects of their positions.
- Ensures that analysts are following the Comprehensive Chemical Hygiene, Safety, and Hazard Communication Plan.

Shealy Environmental Services, Inc.

Page 11 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Ensures that each department has the technical and human resources to perform documented, quality-oriented preparation, analysis, and review in accordance with EQI SOPs, QAMP, policies, and client requirements.
- Oversees the cross-training of analysts and shares resources where appropriate.
- Solves problems and takes corrective action or preventive action to prevent recurrence.
- Provides guidance on instrument troubleshooting.
- Seeks general continuous improvement and implementation of technology.
- Oversees the scheduling of weekday and weekend shifts, rotational schedules, etc. to maximize equipment and facilities.
- Ensures chemicals and supplies are ordered appropriately.
- Ensures performance standards are achieved and documented.
- Implements and oversees data review procedures.
- Supervises the preparation and maintenance of laboratory records.
- Evaluates instrument performance and supervises the calibration, preventative maintenance, and scheduling of repairs.
- Ensures compliance with the TNI standard and the DoD DOE QSM
- Evaluates organic methods for quality and productivity and recommends and implements improvements
- Evaluates organic extraction procedures and recommends and implements improvements
- Evaluates the use of Target Thru-Put and recommends improvements
- Works with vendors to improve products purchased
- Spearheads training and mentoring lab analysts and managers
- Collaborates with QA department to improve SOPs, improve execution of the TNI standard and the DoD DOE QSM, and complete Corrective and Preventive Actions.
- Drives the improvement of and manages CLP, Level 3 and Level 4 packaging group
- Works with laboratory director and IT to continuously improve LIMS
- Reviews data, performs analysis, and plugs in as necessary in response to client workload
- Deputy to the Technical Director

2.3.5. Health and Safety Officer

- Reports to the Laboratory Director
- Performs health and safety audits as required.
- Coordinates refresher health and safety training
- Maintains OSHA "Work-Related Injuries and Illnesses Log"
- Posts annual OSHA Summaries (Form 300A)
- Ensures proper placement, function, and accessibility of all safety equipment.
- Ensures compliance with all state and federal regulations, as outlined in the 29 CFR or as required by SC DHEC.
- Assists the Waste Manager in maintaining the EQI (Shealy) Environmental Integrated Contingency Plan (ME0012C)
- Serves as the Chemical Hygiene Officer
- Responsible for maintenance of the Lockout/Tagout program, foreign soils program, and respiratory protection plan.
- Serves as the Emergency Response Coordinator.
- Hazardous Waste Manager/Hazardous Waste Assistant

Shealy Environmental Services, Inc.

Page 12 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Maintains the Hazardous and Non-Hazardous Laboratory Waste Management Plan (ME0012A).
- Sends quarterly reports to Department of Health and Environmental Control for Large Quantity Generator (Forms DHEC 1962, 1963, and 1965.)
- Issues Notification Form 2701 to DHEC as required.
- Oversees the purging of drums for waste disposal to the appropriate waste disposal facility
- Maintains waste profiles and waste manifests.
- Oversees weekly hazardous waste audits of the hazardous waste central accumulation area
- Oversees the proper disposal of all lab-generated wastes
- Ensures that EQI is compliant with all regulations, state and federal, as outlined in the 40 CFR or as required by SCDHEC.
- Radiation Safety Officer (RSO)
 - Establishes, maintains, enforces and controls Shealy's radiation safety program
 - Acts as the contact person for all regulatory agencies
 - Ensures that all conditions of the radioactive material license are met
 - Responsible for making necessary amendments and notifying the regulatory agency of these amendments
 - Updates the safety program per changes in the regulations.
 - Responsible for maintaining the radioactive material inventory program.
 - Acts as the primary respondent during emergency situations involving radioactive materials.

2.3.6. Project Manager

- Reports to the Laboratory Director
- Acts as liaison between the client and the laboratory.
- Monitors all client analytical and quality requirements.
- Reviews project data packages for completeness and compliance.
- Reviews laboratory project status and works with laboratory personnel to ensure due dates are met.
- Coordinates overall project needs with the laboratory staff to ensure adequate equipment, methods, materials and analysts are available before a project is quoted or accepted.
- Contributes to pre-project planning meetings.
- Ascertains and assures laboratory implementation of project DQOs.
- Assists with regulatory-specific methods and special project requirements.
- Provides price quotations and enters all project specifications into LIMS.
- Coordinates field sampling and sample container shipping.
- Reviews Chain of Custody (COC) information against information entered into LIMS.
- Communicates any COC discrepancies and sample analysis anomalies to client.
- Monitors client-specified turnaround time (TAT).
- Assures deliverable requirements are met.
- Provides updates on project status.
- Reviews, releases, and signs final reports.

Shealy Environmental Services, Inc.

Page 13 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

2.3.7. Human Resources Director

- Responsible for talent acquisition and staffing
- Employment processing including compensation and health and welfare benefits
- Assists in employee onboarding
- Maintains employee records
- Assists with employee relations and retention

2.3.8. IT Specialist / IT Programmer

- Reports to the Laboratory Director
- Responsible for the overall maintenance and development of the LIMS and EQLIMS
- Provides support to all LIMS users
- Performs database maintenance and backup
- Monitors and implements all network security
- Generates all client specific electronic deliverables
- Maintains EQI website

2.3.9. QA Specialist

- Reports to the QAO
- Supports QAO in all QA activities.
- Assists QAO with initiatives for ensuring and improving quality within the operation.
- Monitors and maintains quarterly LOD/LOQ verifications
- Monitors and maintains annual MDL verifications
- Assists QAO in investigating and approving laboratory Corrective and Preventive Actions (CAPAs)
- Assists QAO in administering Proficiency Testing (PT) program in accordance with the TNI standard, DoD and DOE requirements, and individual state requirements.
- Interfaces with regulatory bodies in matters of certification.
- Assists QAO in performing quality internal audits.
- Assists QAO prior to and during external audits.
- Assists QAO in tracking and coordinating responses to external audit findings.
- Tracks external quality related documents.
- Maintains vendor registration and approval
- Assists in generating and updating controlled documents (forms and spreadsheets).
- Tracks, manages and reviews quality documents.
- Responsible for DL, acceptance criteria, LOD and LOQ updates to LIMs, as needed.
- Deputy to the QAO

2.3.10. QA Associate

- Reports to the QAO
- Supports QAO in all QA activities.
- Supervises the preparation, maintenance, and storage of laboratory records.

Shealy Environmental Services, Inc.

Page 14 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Assists QAO with initiatives for ensuring and improving quality within the operation.
- Assists QAO in investigating laboratory NCMs.
- Assists QAO in administering Proficiency Testing (PT) program in accordance with TNI standards, DoD and DOE requirements, and individual state requirements.
- Assists OAO in performing quality internal audits.
- Responsible for generating and updating controlled documents (forms, spreadsheets).
- Responsible for validation of spreadsheets
- Responsible for generation of logbooks per the laboratory's requirements
- Assists in tracking and managing the QAMP, contingency plan, SOPs, and policy updates.
- Tracks employee IDOCs and CDOCs.
- Monitors receipt of certificates of analysis
- Maintains support equipment temperature logs
- Monitors the review of laboratory logbooks
- Manages or performs calibration of laboratory balances and thermometers.
- Responsible for DI water and storage blank testing.
- Responsible for generating quarterly control charts
- Manages employee-training records.

2.3.11. Analytical Manager

- Reports to the Operations Director
- Spearheads method optimization and development
- Performs instrument maintenance and trains analysts in instrument maintenance
- Trains analysts
- Serves as floating senior analyst
- Performs Level I and Level II data review
- Drives continuous improvement efforts
- Responsible for cost-reduction & ordering of supplies
- Serves as a technical advisor
- Involved with the testing and development of LIMS enhancements

2.3.12. Senior Data Package Specialist

- Generation and assembly of all ISM and Level 3 / Level 4 data packages.
- Testing and development of MARRS. Testing and development of LIMS enhancements.
- Primary contact to metals analysis Level 3 / Level 4 data package inquiries.
- Provide feedback to management where CAPAs are required.
- ISM CCS report review and response.
- Training all analysts on applicable features of MARRS and any updates/revisions.
- Level I and Level II data review as needed
- Respond to PMs with regards to adding tests, removing tests, un-batching samples.
- Serve as a backup ICP-AES and ICP-MS analyst as needed.

2.3.13. Data Package Specialist

• Generation and assembly of all SOM and Level 3 / Level 4 data packages.

Shealy Environmental Services, Inc.

Page 15 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Assists with assembly of ISM data packages
- Generation and assembly of PT data packages
- Primary contact for organic Level 3 / Level 4 data package inquires.
- Communicates with Project Managers regarding data package deliverables.
- Level III review of data packages

2.3.14. Field Services Group Leader

- Reports directly to the Laboratory Director on all quality and operational related matters.
- Supervises, guides, and trains field service technicians.
- Ensures field sampling SOPs are followed for all field parameters and activities.
- Maintains proper calibration logs and reviews all field data logs and summaries.
- Coordinates field service scheduling

2.3.15. Organic Extractions Group Leader

- Reports directly to the Operations Director on all quality and operational matters.
- Supervises all organic extractions analysts in all technical and operational aspects.
- Ensures organic extractions department meets all quality requirements and initiatives.
- Manages on time delivery
- Serves as primary contact for rush projects
- Proactively informs Project Managers of late data and instruments down.
- Trains analysts and ensures performance standards are achieved.
- Implements and oversees data review procedures.
- Evaluates instrument performance.
- Ensures that instrument and equipment maintenance is performed and is properly documented.
- Oversees calibration where required.
- Ensures standards, chemicals and supplies are ordered appropriately.
- Seeks continuous improvement and implements new technology.
- Performs annual review of organic extractions department SOPs

2.3.16. Volatiles Group Leader

- Reports directly to the Operations Director on all quality and operational matters.
- Supervises all volatiles analysts in all technical and operational aspects.
- Ensures volatile department meets all quality requirements and initiatives.
- Manages on time delivery
- Serves as primary contact for rush projects
- Proactively informs Project Managers of late data and instruments down.
- Trains analysts and ensures performance standards are achieved.
- Implements and oversees data review procedures.
- Evaluates instrument performance.
- Ensures that instrument and equipment maintenance is performed and is properly documented.
- Oversees calibration where required.

Shealy Environmental Services, Inc.

Page 16 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Ensures standards, chemicals and supplies are ordered appropriately.
- Seeks continuous improvement and implements new technology.
- Performs annual review of volatile department SOPs

2.3.17. Semi-Volatiles Group Leader

- Reports directly to the Operations Director on all quality and operational matters.
- Supervises all semivolatiles analysts in all technical and operational aspects.
- Ensures semivolatile department meets all quality requirements and initiatives.
- Manages on time delivery
- Serves as primary contact for rush projects
- Proactively informs Project Managers of late data and instruments down.
- Trains analysts and ensures performance standards are achieved.
- Implements and oversees data review procedures.
- Evaluates instrument performance.
- Ensures that instrument and equipment maintenance is performed and is properly documented.
- Oversees calibration where required.
- Ensures standards, chemicals and supplies are ordered appropriately.
- Seeks continuous improvement and implements new technology.
- Performs annual review of semivolatile department SOPs

2.3.18. Inorganic Metals Group Leader

- Reports directly to the Operations Director on all quality and operational matters.
- Supervises all inorganic metal analysts in all technical and operational aspects.
- Ensures inorganic metals department meets all quality requirements and initiatives.
- Manages on time delivery
- Serves as primary contact for rush projects
- Proactively informs Project Managers of late data and instruments down.
- Trains analysts and ensures performance standards are achieved.
- Implements and oversees data review procedures.
- Evaluates instrument performance.
- Ensures that instrument and equipment maintenance is performed and is properly documented.
- Oversees calibration where required.
- Ensures standards, chemicals and supplies are ordered appropriately.
- Seeks continuous improvement and implements new technology.
- Performs annual review of inorganic metal department SOPs

2.3.19. Inorganic Non-Metals Group Leader

- Reports directly to the Operations Director on all quality and operational matters.
- Supervises all inorganic non-metals analysts in all technical and operational aspects.
- Ensures inorganic non-metals department meets all quality requirements and initiatives.
- Manages on time delivery

Shealy Environmental Services, Inc.

Page 17 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Serves as primary contact for rush projects
- Proactively informs Project Managers of late data and instruments down.
- Trains analysts and ensures performance standards are achieved.
- Implements and oversees data review procedures.
- Evaluates instrument performance.
- Ensures that instrument and equipment maintenance is performed and is properly documented.
- Oversees calibration where required.
- Ensures standards, chemicals and supplies are ordered appropriately.
- Seeks continuous improvement and implements new technology.
- Performs annual review of inorganic non-metal department SOPs

2.3.20. Sample Receiving Group Leader

- Reports to the Operations Director on all quality and operational matters.
- Supervises all sample receiving custodians in all technical and operational aspects.
- Ensures sample receiving and shipping department meets all quality requirements and initiatives.
- Reviews LIMS sample receiving logins
- Trains custodians and shipping personnel and ensures performance standards are achieved.
- Supports sample receiving and shipping as necessary in response to client workload
- Performs annual review of sample receiving and shipping department SOPs
- Serves as project manager for pre-pay clients
- Performs administrative duties for the front office

2.3.21. Sample Custodian

- Reports directly to the Sample Receiving Group Leader on all quality and operational matters.
- Implements proper sample receiving procedures in accordance with the Sample Receiving SOP.
- Documents anomalies related to samples as received.
- Enters all sample information into the LIMS.
- Monitors that internal chain-of-custody procedures are followed for all samples leaving the sample receiving area.
- Ensures proper sample storage conditions are maintained.
- Assists the Waste Manager to ensure that disposed samples are properly documented.

2.3.22. Analyst / Senior Analyst

- Reports directly to the appropriate Group Leader on all quality and operational matters.
- Follows all health and safety policies and procedures.
- Performs analysis, documentation procedures, and review in accordance with appropriate SOPs, policies, and the QAMP.
- Performs and documents all calibrations and standards preparation.
- Performs and documents equipment maintenance.

Shealy Environmental Services, Inc.

Page 18 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Reports NCMs to the appropriate Group Leader.
- Reviews SOPs under the supervision of the Group Leader

2.4. Quality Management System

The purpose of the EQI Quality Management System (QMS) is to ensure the production of legally defensible data of known quality. The QMS encompasses the necessary documents, policies, instructions, controls, and operating procedures needed to meet client and regulatory requirements relating to the work performed and the data produced. The QAMP is a document which describes the EQI QMS in a clearly written format for use by both our personnel and by our clients.

2.4.1. Quality Responsibility

All EQI employees are accountable for performing their job duties in compliance with all applicable laws, regulations, methods, SOPs, The NELAC Institute (TNI) standard, and the EQI QAMP. Each employee is directly responsible for ensuring the highest quality of his/her work performance. All analysts are required to perform documented initial and continuing demonstrations of capability (IDOC/CDOC) with respect to the analyses they perform. All EQI employees concerned with environmental testing activities are required to familiarize themselves with the QAMP and with the policies and procedures required for their work.

2.4.2. Quality Assurance / Quality Control

Quality Assurance (QA) is defined as set of activities used to ensure the quality in the processes by which laboratory data is generated. For an environmental laboratory, QA provides assurance that established procedures and policies are effective in producing precise and accurate data so that customer requirements are satisfied in a systematic and reliable fashion. Some examples of QA elements are:

- Document control
- Training (demonstration of capability, ethics, etc.)
- Procurement control (vendor approval, subcontract lab approval, certificates of analysis, etc.)
- Internal audits
- Corrective and preventive action (CAPA)

Quality Control (QC) is defined as a set of activities for ensuring that established procedures are effective and successful in producing precise and accurate data. Some examples of QC elements are:

- SOPs that are utilized to ensure uniformity in procedure and parent method compliance.
- Measurement of all aspects of instrument performance to ensure instruments are operating within established statistical control limits.
- Monitoring analysis proficiency through single-blind or duplicate analysis and providing corrective action if necessary.

Shealy Environmental Services, Inc.

Page 19 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

• Utilization of acceptance limits for QC parameters such as method blanks (MB), laboratory control samples (LCS), and matrix spike/matrix spike duplicate (MS/MSD) samples to determine the validity and quality of sample results.

Together, all QA activities and all QC activities combine to form the basis of our QMS. The QAMP is the controlling document that is central to our QMS. It describes our QA/QC efforts and ties in other regulatory documents that are the framework of our QMS.

2.5. Quality System Components

2.5.1. Quality Documents and Records

2.5.1.1. Quality Documents

Quality documents are those documents that establish and control the production of data of known quality and legal defensibility. They define not only quality objectives but also the policies and procedures required to affect high quality. Quality documents are developed, reviewed, approved and controlled as per section 5.1. EQI quality documents include the following:

- The EQI QAMP
- SOPs
- Policies

2.5.1.2. Quality Records

Quality records are those that provide evidence of overall proficient laboratory operation. EQI quality records include but are not limited to the following:

- Logbooks (instrument maintenance, standard preparation, etc.)
- Forms and spreadsheets
- Support equipment Calibration records
- Instrument calibration data
- QC sample data
- Certificates of analysis
- Laboratory accreditations/certifications
- Proficiency testing results
- Audit reports
- Nonconformance memos (NCMs)
- Corrective and Preventive Actions (CAPAs)

2.5.1.3. Project Records

Project Records are those that provide evidence of overall proficient laboratory operation for a specific project. EQI project records include but are not limited to the following:

Shealy Environmental Services, Inc.

Page 20 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Chain-of-Custody forms
- Raw data
- Field data
- Final data reports including case narrative
- QC and calibration results

2.6. Implementation

In order to implement the QMS and ensure that the applicable elements of the quality system are understood, the following items must be in place:

- Appropriate, well-written standard operating procedures (SOPs), policies and QAMP
- Document control system
- Properly qualified employees
- Effective training program
- Ongoing quality improvement initiatives
- Internal auditing program
- Corrective and preventive action program
- Procurement control system
- Effective communication internal and external
- Data verification and validation

3. Personnel Qualifications and Training

3.1. Personnel Qualifications

The laboratory recruits personnel from the university campuses located throughout South Carolina, from other respected environmental laboratories across the country and from other similar industries. Many applied science graduates join EQI as entry-level analysts, and progress, through training and experience, into senior analysts, data reviewers, project managers, and QA personnel. Currently, over 90 percent of our laboratory personnel have degrees in applied science. The average years of experience for most employees is six years with many employees having over ten years of experience in the environmental laboratory business. Detailed synopses of key employees, as noted on the management organizational chart in Figure 2.3-1 and on the Organizational Chart in the addendum, are included in Appendix A.

Prior to hiring, each potential employee must meet certain minimum requirements. These requirements are covered in section 3.1.2 below, which specify the minimum education and experience requirements. The necessary duties of the positions listed below can be found in section 2.2. Experience can be substituted for education at a two to one ratio. For example, eight years of experience is equivalent to four years of schooling. Potential employees must produce proof of academic training, give permission to EQI to verify information via contact with references, and successfully pass a pre-employment drug screen. The final decision to hire is made by the Laboratory Director and the applicable member(s) of management based upon the applicant's qualifications.

Shealy Environmental Services, Inc.

Page 21 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

After hiring, personnel in most analytical positions receive training for a period that lasts from six months to two years, depending upon the level of experience required to competently perform the duties of the position.

3.1.1. Human Resources

In order to ensure that EQI hires and maintains only qualified employees, it has established policies, guidelines, and procedures governing the hiring process. These policies, guidelines, and procedures are elaborated in the EQI (Shealy) Employee Handbook (P-AD-001). A few key areas that apply to quality and the QAMP are as follows:

- Classification of Employees Prerequisites used during hiring process.
- Confidentiality Protection to satisfy the requirements of clients.
- Disciplinary Guidelines Addresses the quality of an individual's work as well as other aspects that affect performance.
- Substance Abuse Outlines the pre-employment and random drug screening requirements EQI has established.

3.1.2. Experience Requirements

3.1.2.1. Organics

- GC and GC/MS analysts must have at least one year of experience in the operation of GC and/or GC/MS instrumentation analyzing environmental samples. Gas chromatographic and/or mass spectral interpretation analysts must have at least one year of experience in the interpretation of data gathered in GC and/or GC/MS analysis. Two years of college or equivalent is required.
- Extractions analysts must have at least one year of experience in the preparation of extracts. Two year degree in science or equivalent is required.

3.1.2.2. Inorganic Metals

- ICP, ICP/MS and CVAA/CVAF analysts must have at least one year of experience in the operation of ICP, ICP/MS and/or CVAA/CVAF instrumentation analyzing environmental samples. ICP, ICP/MS and CVAA/CVAF spectral interpretation analysts must have at least one year experience in the operation and interpretation of ICP, ICP/MS and/or CVAA/CVAF data. Two years of college or equivalent is required.
- Preparation analysts must have a least one year of experience in the preparation of digests. A two year degree in science or equivalent is required.

3.1.2.3. Inorganic Non-Metals and Microbiology

Shealy Environmental Services, Inc.

Page 22 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

• Inorganic and micro analysis and preparation analysts must have a least one year of experience performing inorganic and/or micro prep and analysis. Two year degree in science or equivalent is required.

3.1.2.4. Sample Custodian

• Sample custodians must have a least one year of experience in a similar work environment. Two year degree in science or equivalent is preferred.

3.1.2.5. Shipping Custodian

• Shipping custodians must have at least two years of experience in a similar work environment.

3.1.2.6. Field Service Technician

 Field service technicians must have at least two years of experience in a similar work environment.

3.1.2.7. Group Leader, QA Specialist and QA Associate

 Group Leaders, QA Specialists and QA Associates must have a minimum of a four year science degree or equivalent as well as three years of laboratory experience.

3.1.2.8. Project Manager

• Project Managers must have a minimum of a four year science degree or equivalent and two years of laboratory experience.

3.1.2.9. Health and Safety Officer / Hazardous Waste Manager / Hazardous Waste Assistant and Radiation Safety Officer

- The Health and Safety Officer must have a four year science degree or equivalent, be first aid/CPR certified, a working knowledge of all state and federal regulations governing laboratory health and safety and two years of experience.
- The Hazardous Waste Manager must have a four year science degree, 40 hour HAZWOPER training (with yearly 8 hour refresher training), first aid/CPR certified, and have two years of hazardous waste handling, labeling, and shipping experience.
- The Hazardous Waste Assistant must have a four year science degree and 40 hour HAZWOPER training (with yearly 8 hour refresher training).

Shealy Environmental Services, Inc.

Page 23 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

 The Radiation Safety Officer must have a four year science degree and a working knowledge of the types and quantities of licensed materials found at EQI. A 40 hour radiation safety course presented by an academic institution, a commercial radiation safety consulting company, or a professional organization of radiation protection experts is required. Two years of experience is required.

3.1.2.10. IT Programmer / IT Systems Administrator

• The IT Programmer and the IT Systems Administrator must have a four year computer science degree or equivalent, knowledge of Delphi, SQL, and network management. Two years of experience is required.

3.1.2.11. Senior Management

Laboratory Director, Quality Assurance Officer, Operations Director, Analytical Manager and Technical Director

• Senior management must have a minimum of a four year science degree or equivalent as well as five years laboratory management experience.

NOTE: The laboratory must have a designated full-time staff member meeting the same requirements as the technical director if the technical director is absent for a period of 15 consecutive calendar days. The operations director is the deputy for the technical director in the event of the technical director's absence. In the event that the technical director is absent for 35 or more consecutive days, the DoD and NELAP accreditation authorities must be notified. The technical director cannot be the technical director of more than one accredited environmental laboratory without authorization from the accrediting body.

3.2. Personnel Training

All new hires to the EQI operation receive appropriate levels of training commensurate with their experience, job duties and positions. Our training program is divided into four categories including:

- New Hire Orientation Training
- Health and Safety / Hazardous Waste Orientation Training
- QA Orientation Training
- General Laboratory Training
- Specific Laboratory Training

3.2.1. New Hire Orientation Training

Shealy Environmental Services, Inc.

Page 24 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

All new employees, including technical, clerical, and management are given New Hire Orientation Training. This training occurs typically during the first two to three days after a new hire reports to work and is conducted by the Human Resources Director, Health and Safety Officer, Waste Manager, Operations Director, the Quality Assurance Officer, and/or other members of the management team. When appropriate, additional assistance can be provided by other qualified employees.

Items covered in the new hire orientation training are listed in the New Hire Orientation Training Checklist (ME001A9) and includes but is not limited to: health and safety, confidentiality, ethics, conflict of interest, computer security awareness, sexual harassment, and substance abuse. The newly hired employee signs the checklist to show that he/she understands the information given. A copy of the completed checklist is included in each employee's training file.

3.2.1.1. Ethical Practices / Data Integrity

EQI management is aware that both internal and external pressures can adversely affect an employee's judgment and the quality of the work they perform. As part of our hiring process, all new employees are required to read and sign an ethics policy (ME0012V) that forbids inappropriate, unacceptable, or unethical behavior in the performance of their job duties. At least annually, mandatory ethics training for all employees is conducted by QA, the Laboratory Director, or the Operations Director. As part of this ethics training, the ethics policy is reviewed and each employee is required to sign the policy either handwritten or via EQLIMS. This signed policy is filed with each employee's training records.

In addition, other safeguards against inappropriate behavior and fraud are in place. These include a low employee/group leader ratio, a quality-based performance review system, disciplinary policies and procedures, internal proficiency testing, mandatory multiple-level data reviews, in-depth internal audits, and on-going training in proper and ethical laboratory practices. The laboratory also maintains a mechanism for confidential reporting of data integrity issues by naming a data integrity officer.

As a DoD ELAP laboratory, Shealy must report instances of inappropriate and prohibited laboratory practices, as detailed in the DoD QSM, to our accrediting body within 15 business days of discovery. Discovery includes findings of such inappropriate practices by laboratory staff or customer stakeholders. DoD ELAP laboratories must submit records of associated corrections taken or proposed corrective actions to their accrediting body within 30 business days of discovery.

3.2.1.2. Computer Security Awareness

Computer Security Awareness training is conducted during new employee orientation and is reviewed on an annual basis. This training covers password handling and security measures taken to ensure protection against unauthorized use of EQI computer systems. Further information concerning computer security is found in the Laboratory Information Management System SOP (ME00161).

3.2.1.3. Confidentiality Agreement

Shealy Environmental Services, Inc.

Page 25 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Confidentiality agreement training is conducted during new employee training. All EQI employees are bound by a confidentiality agreement not to divulge client information to other parties to protect client confidentiality, national security, and proprietary rights. See section 5.6 for further information.

3.2.2. Health & Safety / Hazardous Waste Orientation Training

All laboratory new hires are given the health & safety / hazardous waste orientation training. This training is conducted by the Health & Safety Manager or the Hazardous Waste Assistant. The training includes an overview of the Integrated Contingency Plan (ME0012C), evacuation and emergency preparedness, chemical hygiene, chemical safety, radiation awareness and hazardous waste management. The purpose of this training is to familiarize the new hire with EQI's health & safety and hazardous waste policies and practices.

3.2.3. QA Orientation Training

All new hires, including technical, clerical, and management personnel are given the QA orientation training. This training is conducted by the QAO or a member of the management team. This is a training session covering all sections of the QAMP. The trainer also emphasizes those sections of the QAMP that apply to the new hire's position. The purpose of this training is to familiarize the new hire with EQI's quality policies and practices.

3.2.4. General Laboratory Training

All new hires that will be working within the EQI laboratory receive general laboratory training following their New Hire Orientation Training. If a non-laboratory employee changes positions to a laboratory position, he/she also receives general laboratory training.

General laboratory training is conducted during the first few weeks after new hire orientation, and must occur before the individual is deemed qualified to perform sample preparation or analysis. This training is administered by a number of qualified EQI employees including senior analysts, group leaders, the QA department and senior management.

3.2.5. Specific Laboratory Training

Once orientation and general laboratory training are complete, specific laboratory training begins. Specific laboratory training is given to those individuals in order to impart the skills needed for most positions in the laboratory. Specific training is given for each preparation and/or analysis performed at EQI. The purpose of specific laboratory training is to ensure understanding and proficiency of all aspects of the method being performed. Demonstration of understanding and proficiency includes the completion of the following:

 Documentation indicating the review and understanding of the EQI SOP covering the items and topics relevant to the training subject. Shealy Environmental Services, Inc.

Page 26 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Successful completion of an Initial Demonstration of Capability (IDOC) to perform a given
preparation and/or analysis via the independent execution of that preparation and/or analysis
on four consecutive laboratory control samples (LCS; a spiked, clean matrix sample) and
obtaining acceptable levels of precision and accuracy.

• The Training application in EQLIMS is used to systematically document all SOP training as well as ongoing training (section 3.3) and DOCs. The LIMS system is capable of generating a batch of IDOC samples including recoveries and is also capable of searching for LCS samples and creating a batch in order to document Continuing Demonstration of Capability (CDOCs) which is required annually.

Further information concerning IDOCs and CDOCs is found in the Demonstration of Capability SOP (ME001F2).

3.3. Ongoing Training

EQI performs ongoing training for employees on a regular basis. This training includes but is not limited to QA, health and safety, SOP/Policy and departmental specific training. The trainer can be any qualified member of the EQI team. Reviewers and approvers of SOPs and policies are considered trained upon publishing of the document. If no significant changes are made to an SOP or policy then no training is necessary.

Group training is held throughout the year to cover various topics, and may be given by outside companies. Training topics are selected by the trainer, are determined as needed and may be due to changing requirements. If applicable, the trainer fills out the Training Materials Presented Form (ME0024P) or the Employee Specific Training Checklist (ME001LZ) detailing the contents of the training session. The trainees' sign the Training Attendance Record (ME001PJ) or the Employee Specific Training Checklist. A copy of the completed training form is filed in each employee's training folder.

The following training is performed on an annual basis: Integrated Contingency Plan (ME0012C), the QAMP, Ethics Policy (ME0012V) and Computer Security Awareness.

3.4. Quality Assurance Officer Training

The QAO must have experience with and/or training in QA/QC procedures, quality systems and auditing. As needed, the QAO will attend appropriate training events or conferences in order to keep the QAO's expertise current.

3.5. Training Files

The quality department tracks training events and retains training documentation. All laboratory training records including the New Hire Orientation Training Checklist and Demonstration of Capability records are kept in training files maintained by the Quality Assurance Associate.

4. Procurement of Laboratory Materials and Services

Shealy Environmental Services, Inc.

Page 27 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Procurement control of laboratory materials and services is paramount in the establishment and maintenance of data quality. Laboratory materials and services used must meet specified criteria that fulfill all quality needs and requirements if they are to be used to generate legally defensible data.

Another aspect of the establishment of legally defensible data is proper documentation and traceability, which indicates that laboratory materials or services of adequate quality were used in the production of specific data. This task is accomplished with the use of a systematic procedure that establishes guidelines for the procurement of laboratory materials and services which meet or exceed specified requirements. This procedure includes guidelines for vendor approval, sub-contract lab approval and the steps taken in order to procure laboratory materials and services.

Purchased laboratory materials generally consist of consumable supplies, equipment and instruments. Consumable supplies include items such as standards, chemicals, solvents, preservatives, and reagents. Equipment includes items such as glassware, sample containers, gloves, personal protective equipment, and test equipment. Purchased services consist primarily of calibration services for instrumentation and equipment, repair and maintenance of equipment and instrumentation and the subcontracting of analytical services.

EQI's procurement system is outlined in the Procurement of Laboratory Supplies, Services and Equipment SOP (ME0015U). The system includes procedures for vendor selection and approval, purchasing, ordering, receipt and acceptance of laboratory materials and services.

5. Documents and Records

Many of the documents and records listed in section 2.5 require a systematic and controlled approach to creation, approval, distribution, implementation and use. Others are created during the process of laboratory analysis and must be controlled, used and stored appropriately. Records requiring a systematic approach are the QAMP, SOPs, policies, forms and spreadsheets and all logbooks generated as part of the analytical process. The process for managing all records can be found in the Records Management SOP (ME001ID). The Internal Document Requirements policy (ME001CJ) describes the specific elements needed to develop an SOP, a policy or a form. EQI's document control system is described in the Document Control and Distribution SOP (ME001HX). EQI's document control software application, EQLIMS Media, is used to edit, review, approve and publish quality documents. The Spreadsheet Validation SOP (ME001IJ) describes the specific elements needed to develop and validate a spreadsheet.

5.1. QAMP, SOPs and Policies

5.1.1. Establishment and Approval

5.1.1.1. QAMP

The EQI QAMP meets all quality systems requirements as stipulated by the NELAP, DoD DOE QSM, ISO 17025 and USEPA CLP.

Shealy Environmental Services, Inc.

Page 28 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

5.1.1.2. SOPs and Policies

EQI has established and maintains a comprehensive set of SOPs and Policies that govern all laboratory activities including sample collection, laboratory receipt of samples, preparation, analysis, quality assurance, quality control, data reporting, final sample disposition and health and safety. SOPs contain method procedures as well as instrument and equipment calibration procedures and QA/QC requirements. SOPs and Policies are based upon approved United States Environmental Protection Agency (USEPA) Methods, Standard Methods for the Examination of Water and Wastewater, the American Society for Testing and Materials (ASTM) or other approved procedures with specifications indicating specific laboratory instrumentation, corrective action procedures, calibration procedures, reportable analytes, LOQs, health and safety information and etc. Policies may also be based upon regulatory documents such as the DoD DOE QSM, TNI 2009, ISO 17025, NELAC 2003, USEPA CLP, etc. Refer to the addendum for a comprehensive list of currently approved SOPs and Policies.

5.1.2. Review Frequency

The EQI QAMP and all SOPs are reviewed, at a minimum, on an annual basis (± one month) for accuracy and adequacy. Changes are approved by the signatories after a thorough review. Policies are reviewed every 3 years for accuracy and adequacy. SOPs and policies must also be revised whenever procedural method changes or changes to regulations occur. The review is completed to ensure that only current and correct methodology and regulatory guidance is employed by the laboratory and that the SOPs and policies are followed as written.

For the purposes of the EPA CLP Statement of Work (SOW), the QAMP is revised within 14 days anytime any of the conditions listed below exist:

- USEPA modifies the technical requirements of the SOW or the contract;
- USEPA notifies EQI of deficiencies in the QAP document;
- USEPA notifies EQI of deficiencies resulting from USEPA's review of EQI's performance;
- EQI's organization, personnel, facility, equipment, policy, or procedures change;
- EQI identifies deficiencies resulting from the internal review of changes in their organization, personnel, facility, equipment, policy, or procedures.

In addition, for the EPA CLP, changes made to the QAMP that affect policy, reporting, documentation, and quality are clearly marked in the document, the pages dated as to when the changes were implemented, and the amended copies sent to the Regional CLP PO and QATS.

SOPs or policies for processes that have any sort of impact on CLP samples will be amended anytime any of the situations below arise.

- USEPA modifies the technical requirements of the SOW or the contract;
- USEPA notifies the Contractor of deficiencies in their SOP documentation;
- USEPA notifies the Contractor of deficiencies resulting from USEPA's review of the Contractor's performance.

Shealy Environmental Services, Inc.

Page 29 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

CLP SOPs and policies will be amended or new SOPs and policies must be written within 14 days of when the circumstances listed above result in a discrepancy between what was previously described in the SOPs and policies and what is presently occurring at EQI. All changes in the SOPs and policies are clearly marked and a copy is to be sent to the Regional CLP PO and QATS. When new or revised SOPs and policies are prepared, the reason(s) for the change are documented and the new or amended SOPs and policies are maintained on-file at EQI.

5.2. Establishment and Review of Forms and Spreadsheets

5.2.1. Establishment and Approval

EQI utilizes forms for logbook creation and spreadsheets for many of the analytical activities and QA processes performed. Forms and spreadsheets are based upon the QAMP, SOPs, policies, parent methods and other regulatory documents

5.2.2. Review Frequency

Forms and spreadsheets are reviewed every 5 years for accuracy and adequacy. Forms and spreadsheets must also be revised whenever procedural method changes or changes to regulations occur. The review is completed to ensure that only current and correct methodology and regulatory guidance is employed by the laboratory and that the forms and spreadsheets function as intended.

5.3. Control and Distribution of the QAMP, SOPs, Policies, Forms and Spreadsheets

The QAMP and each SOP, policy, form and spreadsheet is assigned a unique tracking number as documented in our Document Control and Distribution SOP (ME001HX). This number is used to track the documents from creation through archival. Each document contains a header on every page which contains specific information as per our Internal Document Requirements policy (ME001CJ). A master list of all SOPs, policies, forms and spreadsheets is maintained by QA.

Certain departments may receive controlled paper copies of these documents. The distribution of all paper copies is recorded in a distribution log to ensure that the current copy is being used. For employees with computer access, current documents can be viewed via EQLIMS Media.

5.4. Analytical Logbooks

An inventory system is maintained for all analytical logbooks. Each logbook is uniquely identified and controlled using a non-removable numbered tag. The logbook inventory database is maintained by QA. Analytical logbooks are kept for a period of not less than five (5) years following completion. Analytical logbooks can be kept for an extended period if a project specific retention period exceeds this requirement. The procedure for generation, control and use of logbooks is found in the Logbook Entry, Generation, Tracking and Review SOP (ME0012T).

5.5. Quality and Project Records Management

Shealy Environmental Services, Inc.

Page 30 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

5.5.1. Analytical Data & LIMS Backup

All hard copy and/or electronic data is retained for a period of at least five (5) years after the year of reporting. All analytical data from LIMS is stored electronically on the server. All data is backed up daily on an on-site backup server and is replicated to remote cloud servers. To ensure ongoing computer operation, maintain data storage capability, and to allow time to shut down the system in an orderly manner, the LIMS server is protected by the facility-wide UPS. Please refer to the LIMS SOP (ME00161) for additional information regarding the archival of electronic data.

5.5.2. Supporting Data

All hard copy supporting data including that previously listed under Quality Records and Project Records is sorted by type or project and filed in storage boxes. The storage boxes are kept at an off-site storage facility for a period no less than five (5) years after generation, or three (3) years for CLP Contract data after submission of the reconciled complete SDG file (CSF), unless an extended period is requested. Additional information concerning hard copy data storage can be found in the Records Management SOP (ME001ID). All electronic supporting data is stored as stated in section 5.5.1.

5.5.3. Data Maintenance Plan

In the event that EQI transfers ownership of the business, or goes out of business, all clients for whom analytical work has been performed for the past 5 years (records retention period) would be contacted to ascertain the desired disposition of their records. Environmental Quantitation Incorporated will ensure the desired disposition is affected.

5.6. Data Confidentiality

EQI considers all project information and generated data as confidential and the property of the client. Client specific information is released to third parties only after consultation with and written approval from the client. If so directed by courts of law or regulatory agencies, EQI will provide required project information and data and will notify the affected client as to the requesting body and the information surrendered.

In addition, all EQI employees are required to sign a confidentiality agreement (ME0022R) not to divulge client information to other parties to protect client confidentiality, national security, and proprietary rights.

6. Computer Hardware and Software

EQI utilizes computers in a variety of ways including:

- In-house designed and programmed Laboratory Information Management System (LIMS & EQLIMS).
- The capture and processing of data from instrumentation.

Shealy Environmental Services, Inc.

Page 31 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- The transfer of data from instrumentation to the LIMS.
- Spreadsheet databases for storage and calculation of data.
- Quality Assurance functions such as document control and training.

The procedures for ensuring and protecting the integrity of data processed in each of these computer systems is discussed below and is based upon the EPA document "2185 – Good Automated Laboratory Practices". The LIMS SOP (ME00161) contains more specific information related to responsibilities, personnel, quality assurance, LIMS raw data, software, security, hardware, testing and record retention. The LIMS User Guide SOP (ME001IS) describes the basic steps for using LIMS.

6.1. Laboratory Information Management System (LIMS / EQLIMS)

The legacy LIMS utilizes a state-of-the-art, open architecture, object oriented relational database developed by the EQI information technology department. The LIMS has been designed and developed to address the current and future needs of the operation's data handling and reporting requirements. LIMS utilizes Microsoft server products which ensures compatibility, stability, and security through standardization and integration.

EQLIMS is a LIMS designed and developed to address the current and future needs of the operation's data handling and reporting requirements written in C#.net. C#.net is a multi-paradigm programming language encompassing strong typing, imperative, declarative, functional, generic, object-oriented (class-based), and component-oriented programming. The code leverages the .NET Framework Class Library (FCL). Microsoft SQL Server, a relational database management system, is used for storing and retrieving data as requested by EQLIMS.

The system is designed so that each module is fully independent of the other modules running within the current session. This allows for proper testing of new modules in a real time environment without compromising existing modules or data, as well as allowing the system security to operate on a module-by-module basis, preventing unauthorized access to critical portions of the system.

The LIMS is based on the following high-level functions: Quoting, Sample Receiving, Sample Management, Electronic Data Handling and Reporting. Currently EQLIMS is used to support Quality Assurance (Document Control, CAPA and Training modules).

6.1.1. Quoting

The LIMS Quoting system allows our project managers to do all client project quoting electronically. This module obtains the client code from the user to provide automatic custom pricing, turnaround time requirements, analytical methodology, specific compound requirements, LOQs, deliverable requirements, and sample scheduling. This captures the project specifications, which forms the front-end module for Sample Receiving.

6.1.2. Sample Receiving

Shealy Environmental Services, Inc. Effective Date: 7/13/2018 Document Number: ME0012K-06

> The Sample Receiving module provides an efficient and reliable method of accurately entering sample parameters into the LIMS. Using the appropriate quote number, the Sample Receiving module automatically obtains the client project specifications. The client's sample identification, the date and time of collection, the number and type of containers received, and other sample specific information are entered into this module. A unique laboratory ID is assigned and holding time and turnaround time management systems are activated.

Page 32 of 100

6.1.3. Sample Management

The LIMS employs a Sample Management module that tracks samples throughout the laboratory (Internal Chain-of-Custody or ICOC), from sample receipt to sample disposal. This module allows the user to rapidly locate samples within the laboratory. This module requires all users to scan each sample's barcode each time the sample moves from one location to another or from one analyst to another. This module also handles sample batching. This procedure allows the user to group like samples together for analysis. This group (Sample Batch) stores the QC information for all samples within that batch.

6.1.4. Electronic Data Handling

The LIMS retrieves data from many data sources throughout the laboratory. Each data source has a custom LIMS batching module for data transfer designed for that particular analysis method. Each of these transfer modules operates independently of each other, yet all of them transfer the data to LIMS in a standard format. This allows the quality control routines to be standardized for all analyses, while providing the flexibility to run specialized routines against the raw data before transfer. The data is transferred to LIMS in preliminary form. Before the data can be reported as final, an analytical group leader or senior level analyst reviews the information for final release. This module also handles manual data entry for methods that have no electronic data capturing means. Data that is manually entered from logbooks or bench sheets is entered twice. If the second entry matches the first entry, the result is final and the next sample result can be entered. If the second entry does not match the first entry, both entries must be repeated until they match. Data is not rounded or adjusted for dry weight prior to manual data entry.

6.1.5. Nonconformance Memo (NCM)

The LIMS includes an application in which analysts can efficiently create nonconformance memos. The application allows the analyst to choose the specific batch and samples associated with the nonconformance, to choose the type of nonconformance and to add any additional information required. The NCM application forwards the nonconformance via email to the appropriate group leader, project manager, QA and the Operations Director for review. See section 10.1 for further information outlining the documentation of nonconformances.

6.1.6. Reporting

Shealy Environmental Services, Inc.
Document Number: ME0012K-06

Effective Date: 7/13/2018

Page 33 of 100

The LIMS utilizes a Delphi reporting engine for reporting. This allows for unlimited report formats. LIMS also has electronic reporting capabilities allowing our data to be delivered or transmitted to the client in all of the popular industry standard formats. LIMS also publishes enrolled client's data to our secure web site, allowing our clients to review the data as soon as it becomes available. The EQLIMS Client Report Management application is a client data repository module which is used for editing report narratives, storage and retrieval of reports.

6.1.7. Document Control

The EQLIMS Document Control application allows for complete electronic document management. It ensures that all quality documents are reviewed and approved and that changes are restricted to authorized personnel and tracked for future referral. Quality documents are securely stored to ensure only authorized access and protection against disaster. EQLIMS Document Control is able to maintain the current document's availability, while simultaneously managing review and changes that will result in the next revision of that same document.

6.1.8. CAPA

EQLIMS is also used to initiate, write, review and approve corrective actions and preventive actions (CAPA) via the CAPA application. The CAPA application has many of the same features as the Document Control application but for the specific purpose of providing an electronic platform for the CAPA process.

6.1.9. Training

EQLIMS Training is an application which allows for automated management of all training tasks, from routing, tracking and maintaining records. This training system offers the capability to provide online exams, sign off for group trainings, and creation of training matrices. The types of training included in this module encompasses SOPs, Policies, Demonstration of Capability, and onsite / offsite training.

6.1.10. Continuing Demonstration of Capability (CDOC)

The LIMS CDOC application allows for the automatic retrieval of previously analyzed standards to be used in generating the necessary CDOC documentation required annually for all analysts.

6.2. Target, AIM and MARRS

6.2.1. Target Thru-Put

6.2.1.1. Target Thru-Put is a chromatographic data processing and reporting software package available on Windows and HP-UX. Target reads raw data files and processed results from chromatographic systems, and provides these tools for GC, LC, MS, and MS/MS techniques. Raw data from EQI's GC and GC/MS instruments are processed using Target Thru-Put before being transferred to an analysis batch in LIMS.

Shealy Environmental Services, Inc.

Page 34 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

6.2.2. AIM

6.2.2.1. AIM is a reporting software which works in tandem with Target Thru-Put. AIM is used to generate all chromatographs, quantitation reports and calibration reports. Analysts use Target Thru-Put in conjunction with the reports generated by AIM to review data.

6.2.3. MARRS

6.2.3.1. The Metals Analytical Review & Reporting System (MARRS) provides a seamless, universal connectivity platform that assimilates and summarizes dynamic analytical instrument data into comprehensive analytical information. Essentially, MARRS bridges the functionality gap between instrument raw data and information delivery. MARRS software integrates inorganic instrumentation to a single point for data handling, automates quality assurance and then assimilates and transfers the data to LIMS. Raw data from ICP-AES, ICP-MS, and mercury instruments are reviewed using MARRS software.

6.3. Industry Standard Software

Industry standard software programs are defined as those which are purchased and widely used without modification to the program itself. This type of software is normally purchased previously tested and verified by the manufacturer. However, once purchased and installed, the program is initially verified for use by using test problems (or reference materials for instrument software) with known solutions (known values) to demonstrate that the program is operational for the desired application. This may be performed by the manufacturer onsite in the laboratory. New instrument software is verified in one of three ways: by analyzing a standard curve, by performing a method detection limit or by performing a demonstration of capability each of which must meet the requirements of the method. All purchased software must be used in accordance with the terms of its software license. Any use of software contrary to its license terms is expressly prohibited by EQI. Wherever audit trail functionality is available as a part of instrumentation software, this function is enabled.

Whenever a program is changed, the change is evaluated to determine if revalidation is necessary. If the software has had features added, test problems or reference materials should be run to demonstrate that the software functions as expected. If software revision changes the basic operation of the program, complete revalidation of the program may be required. The technical director and appropriate group leader are responsible for the generation of the verification data for instrument software as outlined above for new software. Quality assurance maintains the necessary documentation.

Spreadsheets used to acquire and process client data must be documented and re-verified when changes that may affect data quality are made. A test problem, is processed and the results compared to demonstrate that performance of the software is unchanged. Spreadsheets are controlled through locking of cells and assigning passwords to every sheet. They are verified as described in the Spreadsheet Validation SOP (ME001IJ).

6.4. Hardware

Shealy Environmental Services, Inc. Document Number: ME0012K-06

Page 35 of 100 Effective Date: 7/13/2018

The LIMS is a client/server-based system, utilizing industry standard SQL for data manipulation. The LIMS currently runs on a Windows 2008 server, with Microsoft SQL Server 2014 as the database. The LIMS application and database servers are virtual servers and are being hosted on Dual PowerEdge R620 servers with Intel Xeon E5-2630 2.3 GHz processor, 96 GB memory, 2 x 300 GB 6 Gbps SAS Hot-plug hard drives. The physical storage box is an EMC VNXE 3200, ISCSI, 25 900 GB hot-plug hard drives.

6.5. Training

All LIMS users are trained on the menu option/modules that they will be using prior to being given access to that menu option. Training is provided by an experienced person in that module. Because LIMS is windows based and intuitive, training typically will be hands on and relatively short.

All other software users are trained either when new software is installed by the manufacturer or by an experienced software user as a part of job training.

7. Project Planning and Control

Field Collection, Analysis.

Preservation

Documentation

Chain of Custody

Shipped to Laboratory

Field

Client

Field

Client

Technician or

Field Technician

Technician

Quality analytical data generation and reporting is the end product of a complex process dependent upon detailed planning and control efforts. EQI expends extraordinary effort on "project management" from the initial client inquiry, through delivery of the final analytical data, to follow up inquiries after the data is delivered. The process of project management is shown in Figure 7.0-1.

Samples Received: Potential Project/Client COC Completed; Temp. Checked; Sample Preservation Checked: Condition Examined; Custodian Lab # Assigned: Quote Prepared Proper Storage Account Executive from LIMS Project Manager (PM) LIMS sample Sample Information receiving info Entered into LIMS Ouote Review Reviewed by Laboratory Director PM (For large and/or complex projects) Preparation & Analysts Analysis Client Quote Acceptance Data & Q leaders Detailed Project Planning Project Manage Reviewed & Verified Project with Laboratory Manage Ongoing Planning

Report compiled

Data Reported

Follow Up

Laboratory

Associates

Manager

Project

Figure 7.0-1: Process of Project Management

Shealy Environmental Services, Inc.

Page 36 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

7.1. Assignment of a Project Manager

Once a proposal has been accepted, the client is assigned a project manager to control the project from cradle to grave. The project manager is normally the individual who created the quote.

7.2. Quote / Proposal Generation

Project planning begins at the initial client inquiry. This inquiry may range from a verbal request to a very formal and detailed request for quotation. Regardless of the format of the inquiry, a quote / proposal is generated by the quote module in LIMS. The quote module takes into account, at minimum, the following:

- Analyses required
- Regulatory program and certifications required
- Methods required for both preparation and analysis
- Analyses and compounds required
- LOQs required
- "J-values" needed
- Project schedule-duration and time frame
- Deliverable format-EDD, paper, special
- Deliverable requirements-Level 2, 3, 4, other
- Report contact
- Invoicing information
- Comments or special client needs

Most quotes/proposals are generated by either the Project Manager or the Laboratory Director. Very large or complex proposals or ones involving lengthy contractual language may be prepared by the Laboratory Director.

7.3. Quote / Proposal Review

All large quotes are reviewed by the Laboratory Director who determines the impact each project will have on the laboratory. It is at this review step that an assessment is made to determine the laboratory's capacity to perform the quoted work from a standpoint of personnel, materials, analytical instrumentation, etc.

For large or complex projects, this assessment is made with the concurrence of the technical director and laboratory operations. Only after the proposal is thoroughly discussed and deemed within the capacity and technical capability of the laboratory is a quotation submitted to the potential client.

7.4. Detailed Project Planning

Shealy Environmental Services, Inc.

Page 37 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

The most important aspect of project management is the communication of specific client needs and requirements to the laboratory organization. Methods utilized in sample analyses are usually dictated by client and/or permit requirement. Where no method is indicated by the client or permit, the most appropriate method based on the program area (such as drinking water, wastewater, solid and hazardous waste) is selected.

The applicable QC requirements as outlined in the QAMP are dictated by the program area chosen in LIMS. A comprehensive list of the methods routinely performed is detailed in the addendum to this document.

For large or complex projects; those requiring elevated levels of deliverables; those requiring quick turnaround of analysis and data; and those where experience indicates there may be potential analytical problems due to source / sample matrix / etc.; a project review meeting is held by the project manager with the analysts, group leaders, and data package specialists if needed. Project details are discussed and understanding of project particulars is gained. This process is timed to occur before samples arrive at the facility, but not so soon as to lose impact and knowledge gained.

For projects that continue over time, the project manager may conduct on going or refresher meeting to discuss progress and assess that all requirements are being met. The project manager takes the lead role in communicating and affecting changes, when and where needed.

7.5. Contingency Planning

Any effective organization must plan for the "unexpected", and be able to react in an expeditious manner. The EQI management team constantly reviews the following to ensure uninterrupted and successful project completion.

7.5.1. Equipment Capacity / Redundant Instrumentation

EQI reviews work load and equipment capacity on an ongoing basis to determine instrument utilization time. Instruments are not normally utilized at 100% of their theoretical capacity, allowing time for both planned and unplanned maintenance.

EQI also has redundant equipment, in both the inorganic metals analysis and the organic analysis areas, to permit on going processing/analysis even if an instrument is out of service for any prolonged length of time.

In circumstances where a catastrophic outage or instrument failure occurs, customers are contacted promptly to determine if alternate methodology may be appropriate or if out sourcing of analysis is desired.

7.5.2. Staffing

As is true with equipment capacity, the EQI laboratory staffing level is closely watched to ensure that the proper number of qualified employees are available to perform the work on hand and the work planned for the future.

7.5.3. Subcontract Laboratories

Shealy Environmental Services, Inc.

Page 38 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Subcontract laboratories are only utilized if the laboratory is not capable of or certified for a required analysis as part of a complex project (i.e. dioxins/furans, fixed gases, etc.), or if an instrument is inoperable for any extended length of time jeopardizing holding times or client schedules.

For parameters that are regulated or require state and/or federal certification, subcontract laboratories are required to maintain such certification. In any event, we do not subcontract analyses without the client's approval. The subcontract laboratory must be on the approved laboratory list as described in the Procurement of Laboratory Supplies, Services and Equipment SOP (ME0015U).

7.5.4. System Safeguard During Power Failure

All instrument and computer critical circuits within the laboratory are protected with an uninterruptible power supply (UPS) system. Therefore, the LIMS server and all workstations in the building are protected by this system. The system consists of a Mitsubishi Electric 9700 Series 225 kVA UPS is equipped with two battery packs. The UPS ensures ongoing computer operation to maintain data storage capability, and time to shut down all computer systems in an orderly manner if required. Additionally, it filters the local current to supply conditioned power to all instrumentation and computer systems. Refer to the LIMS SOP (ME00161) regarding analytical data and LIMS backup procedures.

8. EQI Operations

8.1. Physical Facility

The analytical laboratory and corporate offices of EQI are located in West Columbia, South Carolina at 106 Vantage Point Drive which is near the intersection of Interstates 26 and 77 in the Overlook Business Park. EQI's client service centers are located in the Raleigh, North Carolina, Charlotte, North Carolina, Greenville, South Carolina, and Charleston, South Carolina areas.

The 15,000 square foot building was designed and constructed in 1992, and offers many state-of-the-art technological features.

The building's unique computer controlled closed system (chiller/boiler) seven-module cooling and heating system maintains negative, atmospheric, or positive pressure in seven general work areas. This system has been balanced with the laboratory's 14 fume hoods and outside air to provide the appropriate pressure to each work area.

The facility includes seven different laboratory areas: Sample Receiving, Organic Extractions, Inorganic Non-metals / Microbiology, Inorganic Metals, Semi-volatiles, Volatiles and Chemical Storage / Waste Staging. A summary of each area is provided in section 8.2.

Other facility features include data review/processing areas separate from the preparation and analysis laboratories, an efficient sample receiving area, three walk-in coolers for proper sample storage, and a centralized and secure LIMS server area.

Shealy Environmental Services, Inc.

Page 39 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

An extremely important part of the operation of the EQI laboratories is the assurance and maintenance of a safe and clean facility. This extends to proper lighting, ventilation, fume control, temperature control, and a supply of stable power. We maintain contract services for general building cleaning as well as equipment and instrument repair. Our analysts are also trained to repair the equipment they operate.

The Laboratory Director and the Technical Director, working together with group leaders and analysts have the responsibility to ensure that samples are stored to eliminate, as much as possible, the chance of contamination, that work areas are equipped with adequate counter, hood, and operational space, and that work areas are free from contamination which might impact analysis.

A current layout of the facility is included in Figure 8.1-1.

FBR MICRO-BIOLOGY LAB CONFERENCE ORGANIC GPC & INORGANIC LAB MBR EXTRACTIONS PREP (BOD LAB) LAB LAB OFFICE INORGANIC OFFICE SPACE FI EMENTARY NEUTRALIZATION LIQUID-LIQUID WAI K-IN TCLP **EXTRACTION** LAB LAB LOADING 100' (EXISTING) SVOC DATA PROCESSING C-MS/MS LAB MBR OFFICE STORAGE/ LOBBY METALS MECHANICAL DATA OFFICE OFFICE PROCESSING BOTTLE DATA SUPPLIE SHIPPING FBR CENTER SUPPLIES METALS DIGESTION VOC LAB LAB SAMPLE SEMI-VOA ICP/ICP-MS RECEIVING LAB VOC PREP WALK-IN VOA DATA MERCURY LAB COOLER PROCESSING - 130

Figure 8.1-1: EQI Facility Layout

8.2. Laboratory Areas

8.2.1. Sample Receiving

Shealy Environmental Services, Inc.

Page 40 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

All samples received at the laboratory originate in the sample receiving department. Samples received are inspected for proper preservation, physical problems, etc., and are bar coded for sample tracking and disposition. After samples are received and inspected, they are entered into LIMS as discussed in Section 8.4. All samples except volatiles are stored in a large walk-in cooler in the sample receiving area. Volatile samples are stored in either the volatiles walk-in cooler or in various matrix segregated coolers in the volatiles laboratory.

All samples are released to analysts via bar code scanning and internal chain of custody (ICOC) procedures. A fume hood is used in sample receiving for ventilation while opening sample coolers as well as for samples that require ventilation.

8.2.2. Organic Extractions

The organic extractions area operates under negative pressure to prevent the migration of airborne contamination into other areas. Organic extractions and leaching procedures are completed in four separate but contiguous rooms each equipped with fume hoods and airflow technology designed to quickly remove solvent fumes. The four areas are as follows:

- Microwave Reaction System & TCLP/SPLP Room This room is dedicated to microwave extraction and leaching procedures. The room includes one Microwave Extraction System for organic soil extractions and two independent 12-station rotators that are used to perform leaching procedures. This room is maintained at 23 +/- 2 °C.
- Continuous Liquid-Liquid Extractions (CLLE) Room This is a dedicated room equipped to perform 76 separate CLLE simultaneously. A point of use solvent delivery system provides methylene chloride dispensing. This system eliminates the disposal of over 700 glass bottles and packaging materials per year, reduces labor costs, and significantly reduces our analysts' exposure to methylene chloride vapors. This room is maintained on a negative air pressure basis, preventing solvent migration to other laboratory areas.
- Main Extraction Area This area is equipped with five 8-foot high efficiency fume hoods. Each fume hood is utilized for a dedicated process as follows: dual-horn sonicator used for soil sample extraction, Turbovap concentrators, water bath and concentration station, and separatory funnel extraction of aqueous samples. Four muffle furnaces are used to decontaminate glassware after each use. This area is maintained on a negative air pressure basis, preventing solvent migration to other laboratory areas.
- GPC Area This area contains two gel permeation chromatography (GPC) instruments and a 4-foot fume hood.

8.2.3. Volatiles Laboratory

Shealy Environmental Services, Inc.

Page 41 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

The volatile organic analysis area operates under positive pressure to prevent the influx of airborne contamination. This spacious laboratory is located on the opposite corner of the facility from the extractions laboratory. Volatile analysis is conducted in a spacious room located in the opposite corner of the facility from the organic extraction area (also in order to prevent the influx of airborne contamination). A walk-in cooler is located inside this laboratory is dedicated to the storage of volatile aqueous samples. The temperature of the walk-in cooler is monitored and if found out of spec, management is contacted automatically. Major instrumentation includes eight GC/MS instruments with purge & trap concentrators and various autosamplers, a dual GC/FID system configured for dissolved gases and Direct Aqueous Injection (DAI), and one GC/PID/FID system with a purge & trap concentrator and autosampler. Additionally, GC/PID/FID interfaced with a headspace analyzer is used for screening samples prior to analysis as deemed necessary. Trip blanks, field QC, and samples with known historical results may not be screened.

The volatile organic analysis laboratory has a dedicated computer controlled heating/cooling system. Room pressure is maintained positive at all times to prevent the influx of airborne contamination. The GC and GC/MS instrumentation, purge and trap concentrators, and autosamplers are supplied with high-purity helium using a stainless steel gas delivery system equipped with an automatic switching manifold. The helium cylinders reside in a secure storage bay located near the loading dock in the back of the facility. This system ensures an uninterrupted supply of reagent grade helium and eliminates the need for analysts to transport cylinders. Hydrogen and zero-air generators are located in this laboratory supplying an uninterrupted source of high-purity gases to the instruments.

Additionally, all analytical instruments are networked to the LIMS via Target software, permitting uploading of data into the LIMS for review and report preparation.

8.2.4. Semivolatiles Laboratory

The semivolatile organics analysis area operates under negative pressure. A hydrogen and zero-air generator supply uninterrupted high purity gases to the GCs. Semivolatile analysis, consisting of BNAs, pesticides, PCB, herbicides, explosives, TPH-DRO, EDB/DBCP analysis is conducted in this laboratory. The semivolatile laboratory contains four GC/MS instruments with autosamplers, five dual GC/ECD instruments and two dual GC/FID instruments.

The semivolatile area has a dedicated computer controlled heating/cooling system. This room is maintained on a negative air pressure basis, preventing solvent migration to other laboratory areas. The GC/MS instruments are supplied with high-purity helium using a stainless steel gas delivery system equipped with an automatic switching manifold. The helium cylinders reside in a secure storage bay located near the loading dock in the back of the facility. This system ensures an uninterrupted supply of purified helium and eliminates the need for analysts to transport cylinders. Hydrogen and zero-air generators supply uninterrupted high purity gases to the GCs. A micro-bulk liquid nitrogen tank provides an uninterrupted supply of nitrogen to the appropriate instrumentation.

Additionally, all analytical instruments are networked to the LIMS via Target software, permitting uploading of data to the LIMS for review and report preparation.

Shealy Environmental Services, Inc.

Page 42 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

8.2.5. HPLC & LC/MS/MS Laboratory

This laboratory has a dedicated eight-foot fume hood for performing perfluoroalkyl substance and polyfluoroalkyl substance (PFAS) sample preparation. A micro-bulk liquid nitrogen tank provides an uninterrupted supply of nitrogen to the HPLC-MS/MS instrument. Explosive and PFAS analysis is conducted in this laboratory. The laboratory contains two HPLC instruments (VWD and DAD detectors) and one HPLC-MS/MS instrument. The laboratory has a dedicated computer controlled heating and cooling system. The system maintains atmospheric to negative pressures depending on the fume hood use.

8.2.6. Inorganic-Metals Preparation & Instrumentation Laboratory

The metals preparation and instrumentation laboratory consists of three rooms, one for sample digestion, digestate staging and storage, the second for low-level mercury and mercury analysis, and the third for ICP and ICP-MS analyses.

The metals preparation area is equipped with polypropylene casework, two eight-foot polypropylene hoods, one six-foot polypropylene hood for low level mercury, acid-resistant counter tops and sink, and vented sample storage cabinets. The entire exhaust pathway for the polypropylene hoods is PVC including the stacks. Because digestions are performed in a plastic, completely metals-free environment, contamination is minimized. Digestions are performed in hot blocks using disposable digestion tubes. The digestion room has a dedicated computer controlled heating/cooling system that maintains a negative laboratory pressure to ensure acid fumes do not migrate into other laboratory areas. Also, the digestion room has a clean room ceiling.

The metals instrumentation laboratories include two Thermo Scientific Inductively Coupled Plasma (ICP) trace instruments (iCAP 6500, iCAP 7600), two Thermo Scientific ICP-MS instruments (X Series 2, iCAP Q), a Teledyne Technologies automated Quick Trace M8000 Mercury Analyzer (CVAF), and two Leeman automated CVAA mercury analyzers. The instrument rooms have a dedicated computer controlled heating/cooling system. The pressure of both rooms is maintained positive at all times to prevent the influx of acid fumes and reduce airborne particulate contamination. A 900-gallon bulk liquid argon tank provides an uninterrupted supply of argon to all the appropriate instrumentation. The metals analysis labs have clean room ceilings.

8.2.7. Inorganic Non-Metals and Microbiology Laboratory

The inorganic non-metals and microbiology laboratory consists of four contiguous rooms. This laboratory is equipped with three fume hoods, multiple faucets providing tap and deionized water, multiple sinks, a walk-in sample cooler, and multiple LIMS workstations. Major instrumentation includes two Aquakem 200 discrete analyzers, three Dionex / Thermo Scientific ion chromatography (IC) systems, an autotitrator, one OI TOC analyzer, two OI auto chemistry analyzers, one Lachat auto analyzer, two analytical balances, one Hach spectrophotometer, several incubators, an autoclave, four midi-distillation blocks, three cyanide midi-digestion blocks, two cyanide micro- distillation blocks, and various other instruments and other scientific equipment.

Shealy Environmental Services, Inc.

Page 43 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

The inorganic non-metals laboratory has a dedicated computer controlled heating and cooling system. The system maintains atmospheric to negative pressures depending on the fume hood use.

8.2.8. Waste Accumulation and Chemical Storage

EQI is classified as a Large Quantity Generator (LQG) of hazardous waste as defined under 40 CFR Part 261. As a LQG, EQI follows all generation, management, security, emergency preparedness, and pre-transport requirements as set required by 40 CFR Part 262. Additionally, EQI ensures compliance with all state and local requirements administered by the South Carolina Department of Health and Environmental Control (SC DHEC).

A 600 square foot building, detached from the main building, is utilized as a central accumulation area. Hazardous wastes may be staged and accumulated in this area for up to 90 days prior to pick-up by a licensed waste transporter. EQI also utilizes satellite accumulation areas, located throughout the laboratory, to accumulate wastes at the point of generation. The Hazardous and Non-Hazardous Waste Management Plan (ME0012A) includes specific information regarding EQI's waste management practices and policies.

To maintain customer confidentiality, all sample container labels are rendered illegible prior to container disposal. These procedures are outlined in the Destruction and Disposal of Empty Sample Containers SOP (ME001H7).

Bulk chemicals are stored in appropriately labeled storage or safety cabinets located throughout laboratory areas. Overflow solvent storage is located in the loading dock area. If chemicals are received when all cabinets are full, bottles are kept in the packaged boxes they were received in until space becomes available. Chemical storage policies are located in the Comprehensive Chemical Hygiene, Safety, and Hazard Communication Plan (ME0012D).

8.3. Equipment and Services

8.3.1. Equipment Control

All major equipment and instruments are assigned a unique identifying number and are tracked via the Major Operational Equipment List (ME001PM) which is maintained by QA. The Major Operational Equipment List can be found in the addendum to this document. This list establishes a baseline of our operational capability.

8.3.2. Equipment Maintenance

Shealy Environmental Services, Inc.
Document Number: ME0012K-06

The maintenance of the operational equipment and instruments EQI employs is performed through a combination of contract maintenance services and the skills of our well-trained analytical employees. Preventative maintenance as well as most major repair occurs on site. Frequency of maintenance and the types of maintenance performed is determined by both the manufacturer's recommendations and professional experience. The Group Leader evaluates if the problem with the subject equipment may have affected previously analyzed samples. If such a problem is identified, the Group Leader must report this to the technical director for further action. A passing calibration is performed post repair/maintenance as required and no samples are analyzed until such a calibration is generated. The Group Leader is responsible for ensuring that regular maintenance is performed in a timely manner. Maintenance logbooks are utilized to record such maintenance as well as repairs. Maintenance performed on support equipment is documented in the Support Equipment Repair and Maintenance log (ME001PC).

Page 44 of 100

Effective Date: 7/13/2018

8.3.3. Deionized Water System

Many analyses require the use of high purity water. EQI employs a series of deionized (DI) water tanks to purify the incoming water to ASTM Type I specifications for use by the laboratory. The resistivity of the water is read on a daily basis via an in-line resistivity meter. The resistivity is also constantly monitored by an indicator light, which is located on the first resin tank. When the light changes color, this indicates that the system needs to be serviced. In order to further eliminate problem volatile organic contaminants, the in-house DI water is purified via an activated carbon filter and ultra-filtration at the point of use in the Volatiles laboratory. This water is used for the preparation of standards, blanks, and dilutions associated with volatile organic analysis. Lastly, the DI water is tested on a regular basis for TOC, metals, volatile organic compounds, ammonia, TRC and HPC.

EQI also provides evidence of contaminant free water through the use of method and instrument blanks for all analytical methods. The blank data is stored with the sample raw data as QC.

The Deionized Water System and Storage Blank Testing SOP (ME0012S) contains more detailed information concerning EQI's in-house DIW.

8.3.4. Gases and Solvents

In applications where instrumentation is not supplied gas from an in-house generator, only high-purity grade gases from approved suppliers are utilized. These gases are typically furthered purified using appropriate in-house purification systems, which remove moisture, oxygen, hydrocarbons, and other contaminants.

Nitrogen and Argon gas are piped into the appropriate laboratory from outside bulk tanks. Helium gas is delivered in cylinders which are stored accessible to the appropriate instruments within the laboratory. Hydrogen and zero-air generators supply uninterrupted high purity gases to the appropriate instruments.

Shealy Environmental Services, Inc.

Page 45 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Solvents are of appropriate grade for the application (at least ACS grade up to high-purity grade) and are purchased from approved suppliers. Methylene chloride is utilized as a solvent in the extractions lab and is piped in from outside tanks. All other solvents are purchased in smaller amounts and stored in proper enclosures meeting code requirements.

8.3.5. Glassware Cleaning

All vessels or containers used in analytical or preparation procedures are purchased and certified clean if disposable or washed in accordance with the Glassware Washing SOP (ME001IV) to ensure no contaminants are introduced into the process.

8.3.6. Chemical Storage

Chemicals are purchased from approved suppliers and inventoried in minimum amounts to prevent waste due to non-usage. All chemicals are inventoried on a monthly basis for shelf life and those approaching expiration are properly disposed of. Acids and bases are stored separately in marked cabinets. Flammable solvents are stored in proper enclosures meeting code requirements.

8.3.7. Security and Loss Control

The laboratory has a number of security features to prevent unauthorized access or loss of property.

- The entire sample receiving area and all analytical areas of the laboratory are secured 24 hours a day, every day, with a secure keypad key fob entry system.
- The entry can only be accessed using an electronic key fob system during business and non-business hours.
- During business hours, the front entry is accessible to the public. Beyond the front entry is a fully enclosed lobby. Entry into the interior of the building from the lobby can only be accessed using an electronic key fob system during business and non-business hours.
- After hours, the building is secured by barrier alarms and motion detectors connected to a central, off-site security organization.
- The local police department makes several inspections of the building perimeter each night.
- Hard copy records are securely stored off-site for a period of no less than five years.
- Smoke detection devices are installed in all seven heating and cooling systems and connected to a central off-site security organization.
- Bulk storage of chemicals and accumulation of waste is separate from the main laboratory building preventing loss or downtime if a fire or a spill should occur.
- Adequate fire extinguisher and coverage is maintained.

8.4. Sample Processing

The sample processing operation includes the following:

• Sample collection supplies

Shealy Environmental Services, Inc.

Page 46 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- Field collection operation
- Laboratory sample handling process

8.4.1. Sample Collection Supplies

8.4.1.1. Sample Containers

Control of the quality of laboratory analyses begins with the selection of the proper sampling container and preservative for the sample to be collected. EQI supplies new pre-cleaned, pre-labeled, certified and traceable, pre-preserved sample containers for all sampling events. Additional field quality control sample materials and supplies are included as required. The documentation certifying container cleanliness is available as supplied by the container vendor. Proper sample containers by analysis type are listed in the addendum to this document.

8.4.1.1.1. **Sample Preservation**

The stability of most analytes decreases as a function of time. Sample preservation aids in stabilizing samples, allowing for adequate analysis time in the laboratory.

Sample preservation is normally achieved by adding a chemical stabilizer and/or through a physical means such as lowering the temperature of the sample. EQI provides chemically pre-preserved sample containers for certain analyses to all clients. Analyses that require refrigeration require ice. Proper sample preservatives by analyte are listed in the addendum to this document.

8.4.1.2. Shipping Containers

Shipping containers are sealed enclosures in which sample containers are securely stored when in transit from the collection site to the laboratory. The most prevalent type of shipping container used is an insulated cooler which is durable, resists crushing and provides a measure of temperature insulation. EQI supplies shipping containers of various sizes and in sufficient numbers in order to allow samples to be packed in an upright position. Bubble wrap packing material is also supplied in order to provide shock absorbency so as to prevent sample container breakage during transit. In addition, absorbent padding is used when sending bottles that contain preservatives. All EQI coolers are cleaned to prevent contamination before they are supplied to customers.

During a collection operation, the sample collector must ensure that the cooler is clean and that samples are placed upright in the cooler with adequate shock protection. The samples must be packed with adequate ice to allow a laboratory receipt temperature of $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$. If samples are shipped by commercial courier, the ice must be contained in leak resistant, sealable bags.

Shealy Environmental Services, Inc.

Page 47 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

EQI provides sampling kits with chain of custody (COC) records as well as new, prelabeled, certified and traceable, pre-preserved sample containers and temperature blanks. Other project specific requirements such as cooler custody seals, trip blanks, and etc. are provided upon request. When sampling kits are shipped to a client, applicable Department of Transportation or International Air Transport Association regulations are followed.

The Sample Container Shipping SOP (ME001DS) outlines the sample container shipping procedures in more detail.

8.4.2. Field Collection Operation & Sample Transfer

EQI employs a team of field sampling technicians whose efforts are directed by comprehensive field sampling and analysis SOPs. Whether EQI performs field collection or analysis for a given project, or the client employs its own field sampling personnel, each must adhere to regulatory established procedures to provide samples and/or data that accurately represent the relevant matrix.

All project sampling requirements must be planned and communicated in advance of activating a sampling event. Assurance of sample integrity throughout the entire process includes the use of proper:

- Containers of adequate volume with the appropriate preservatives
- Sampling equipment
- Sampling techniques
- Field cleaning techniques
- QC sample collection techniques and frequency
- Measurement of field parameters such as dissolved oxygen, pH, total residual chlorine, conductivity, and temperature
- Data documentation

EQI's Field Technicians maintain proper field collection data sheets that record ambient conditions and abnormalities encountered during the collection process. They document all aspects of the field collection process including visual observations, sampling equipment information, field analytical information, and any other data related to the sampling event. All measurement results and calibration data for field measurement equipment are recorded

A self-adhesive, water resistant label is attached to each sample container and the following information is recorded using indelible ink:

- Client name
- Field identification or sample station identification
- Sample collection date and time
- Sample preservation
- Analyses required
- Field technician initials

Shealy Environmental Services, Inc.

Page 48 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

A COC form documents each sampling event. It is evidence of the proper collection, shipment, laboratory receipt, and custody of samples. The COC is an accurate, written record which documents the possession of samples from the moment of collection through laboratory receipt, analysis, and disposition. In general, the chain of custody provides the following documentation:

- Client name, address, telephone number, contact person, and if applicable the purchase order number
- The sample ID such as location or station number, the date and time of collection, and the type of sample, either grab or composite
- The total number of sample containers
- The preservation type
- The analysis required
- Other pertinent data or instructions
- The samplers signature and signatures of any other persons to which samples have been relinquished

A copy of the EQI COC is included as Figure 8.4-1 and a copy of the CWA / NPDES COC is included as Figure 8.4-2. EQI field collection personnel ensure that the COC is completed fully, including the information bulleted above.

Finally, it is imperative that samples be shipped and received in the laboratory in an expeditious manner. Whether EQI personnel or others collect the samples, they should be hand delivered or transported to ensure timely laboratory receipt.

It must be noted that proper "custody" of samples must be maintained throughout the collection, transfer, receipt, and analysis process. A sample is in one's possession or is in custody if:

- It is in a person's possession; or
- It is in view after being in possession; or
- It is locked in a secure area after being in possession; or
- It is in a designated secure area, accessible only to authorized personnel.

In the event that packages are transferred by a common carrier, the receipts verifying custody by the common carrier are retained and are attached to the permanent COC document.

Shealy Environmental Services, Inc.

Page 49 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Figure 8.4-1: Chain-of-Custody Form

SHEALY Chain of	Custo	dy Record		Van	tag	ge P	oint 803	Driv	e • ' 1-97	Wes	st C Fa	olun x No	nbia	, SC	E S, I 29 91-9	172					Νι	ımb	er	
Client	Report	Report to Contact									Telephone No. / E-mail							Quote No.						
Address	Sampler's Signature										Analysis (Attach list if more space is needed)							Page of						
City State Zip Code				XPrinted Name																			r ago	
Project Name																								Laboratory Lot Number
Project No.		P.O. No.	/	rab	boons	M	atrix		No of Containers by Preservative Type															Laboratory Lot Normber
Sample ID / Description (Containers for each sample may be combine	ed on one line.)	Date	Time	0.00	TO TO THE PARTY OF	Solid	Agreois	Unpries.	M2SO4	HANOS	NC/	NaOH	5035 ACC											Remarks / Cooler I.D.
					+			-																
					+			+																
					İ			İ																
					1			-	-	ļ.,														
				+				+	-															
																	1							
					1																			
Turn Around Time Required (Prior lab ☐ Standard ☐ Rush (Specify)	approval requ	ired for expedited TAT.				Diene	acal h	e lah				ard lo				kin krit	nt [Daison		nknown	QC	: Requi	remen	its (Specify)
□ Standard □ Rush (Specify) □ Return to Client □ Sposal by Li 1. Relinquished by Date Time					Lau	Non-Hazard Flammable Skin Irritant Poison Unk 1. Received by							IIKIIOWII	Date			Time							
2. Relinquished by Date					Time				2. Received by												Dat	Date 1		Time
3. Relinquished by	Date	Date Time				3. Received by							Date			Time								
4. Relinquished by Da						Tim	6		4. L	abon	atory	rece	ived	by							Dat	10		Time
1 TO BE STOLEN BELLEVIS OF STOLEN STO							LAB USE ONLY Received on ice (Circle) Yes No toe Pack Receipt Temp																	

DISTRIBUTION: WHITE & YELLOW-Return to laboratory with Sample(s), PINK-Field/Client Copy

Document Number: F-AD-133 Effective Date: 08-01-2014

Shealy Environmental Services, Inc.

Page 50 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Figure 8.4-2: CWA/NPDES Chain-of-Custody Form

SHEALY Ch		\ / NPDES Custody R		7		We	est C	Environ 106 Vo Columb 803-7	antago oia, So	e Poir outh C	nt Driv Carolin Fax N	/e na 29	172		1		Nur	nbei	r	
Client Report to Contact										Sampler (Printed Name)									Quote No.	
Address		**********	Telephor	ie No.						1		200	(i.e., p	H, tem	p, DO)	can b	e reco	orded b	pelow	Page of
City	State	Zip Code	Preser	vative		-11-2-5														Number of Containers
			1. Unpres.	4. HNO3					1											Container Type: P=Plastic G=Gla
roject			2. NaOH	5. HCI					1	_	_		_					_		Preservative (use code on le
ame		In a v	3. H2SO4	6. Sodium 1		77.00	-	1	_ →		1									Lot No.
roject lumber		P.O Num	ber		rab	Sample	N/A pe	Matri GW DI	S											
Sample ID / Description (Containers for each sample may be combined on one line) Collection Date				Collection Time (military)	G=Grab C=Compos	Collection Sample Temp°C	Chlorinated Y/N	WW HW S=Solid	↓ Ana											
		Start					Ť													Remarks / Cooler ID
		Finish			1															
a, and a section		Start					\vdash	0.00	-											
		Finish			1															
		Start						1	1											
		Finish			1															
		Start						1	7						-					
		Finish			1															
		Start																\vdash		
		Finish			1						1									
urn Around Time Requir			r expedited To	Sample Dis		D Dis	posal	200 20002	QC Red	uireme	ents (S	pecify)		100000	ble Ha				in Irritan	t □Poison □Unknown
1. Relinquished by /				Date					Received by							ammable □Skin Irritan Date			Time	
2. Relinquished by			Date		Time		-	2. Rece	ived by	ed by						Date			Time	
3. Relinquished by			Date		Time			3. Received by							Date			Time		
4. Relinquished by			Č II (A	Date		Time		-	4. Labo	t. Laboratory Received by Date								Time		
		nples are re		or four week		om			LAB US		Y Check)	пνο	s 🗆 N	o 🗆 Ice	Pack	Bacair	ot Temp		°C	Temp. Blank □ Y / □ N

8.4.3. Laboratory Sample Handling Process

EQI utilizes a comprehensive SOP (Sample Receiving; ME0013H) detailing the prerequisites for proper sample receipt and the sample receiving operation. The following sections describe the general process.

8.4.3.1. Sample Receiving

Full time sample receiving custodians receive all samples. At receipt, the custodians perform the following:

- Examines the shipping container for security/damage
- Opens the shipping container and examines the contents for security/damage
- Documents the temperature of samples as received
- Checks chemical preservation of samples
- Compares samples received (quantity & type) against the COC information
- Verifies that sample holding times are not expired

Shealy Environmental Services, Inc.

Page 51 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Signs and dates the COC after shipment is accepted
 Completes a Sample Receipt Checklist (SRC) form (Figure 8.4-3) for each
 shipment received. If anomalies are noted, the Sample Receiving Technician or the
 project manager must resolve the deviation internally and/or notify the client to
 resolve the anomaly.

- The SRC and COC are scanned to be included in the client report. The SRC form is affixed to a hard copy of the chain of custody and stored appropriately.
- Assigns a unique laboratory control number and attaches a bar coded identification sticker to each sample container.
- Places all samples into the appropriate secure storage cooler and/or alerts analysts to short holding time samples.
- For samples that are received under the laboratory's CLP contract additional procedures are performed as outlined in the sample receiving SOP and the SOM02.4 and ISM02.4 SOWs.

After samples are received, the sample receiving custodian enters all appropriate chain of custody data into the LIMS. Further assessments are made regarding method holding times, as it is imperative that samples are analyzed within the stipulated holding time. Analyses with the holding time "analyze immediately" are normally field parameters to be measured at the time of collection. If these field parameters are performed in the laboratory, proper data qualifiers are indicated on the report.

EQI is responsible for meeting all holding times for properly preserved samples received within 48 hours of collection, or within one-half the holding time, whichever is shortest. Short holding time samples such as those for BOD, fecal coliform, hexavalent chromium, etc., require project manager or client notice to the laboratory to ensure analysis within the holding time.

Shealy Environmental Services, Inc.

Page 52 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Figure 8.4-3: Sample Receipt Checklist

Shealy Environmental Services, Inc. Document Number: ME0018C-08

Page 1 of 1 Effective Date: 03/07/2017 Expiry Date: 03/07/2022

Sample Receipt Checklist (SRC)

Clier	nt:		Cooler Inspected by/date:/ Lot #:									
Means of	receipt:	SESI	□ Client □ UPS □ FedEx □ Other									
Yes □	No		1. Were custody seals present on the cooler?									
Yes □	No	□ N	A 2. If custody seals were present, were they intact and unbroken?									
pH strip I	D:		Cl strip ID:									
Cooler ID	Original	tempera	ture upon receipt/Derived (corrected) temperature upon receipt:									
/		_°C	°C°C°C									
	-		ank Against Bottles IR Gun ID: IR Gun Correction Factor: <u>°C</u>									
Method o	of coolant:	□ Wet	<u> </u>									
Yes □	PM was Notified by: phone / email / face-to-face (circle one).											
Yes □	No □	NA □	4. Is the commercial courier's packing slip attached to this form?									
Yes □	No □		5. Were proper custody procedures (relinquished/received) followed?									
Yes □	No □		6. Were sample IDs listed on the COC?									
Yes □	No □		7. Were sample IDs listed on all sample containers?									
Yes □	No □		8. Was collection date & time listed on the COC?									
Yes □	No □		9. Was collection date & time listed on all sample containers?									
Yes □	No □		10. Did all container label information (ID, date, time) agree with the COC?									
Yes □	No □		11. Were tests to be performed listed on the COC?									
Yes □	No □		12. Did all samples arrive in the proper containers for each test and/or in good condition (unbroken, lids on, etc.)?									
Yes □	No □		13. Was adequate sample volume available?									
Yes □	No □		14. Were all samples received within ½ the holding time or 48 hours, whichever comes first?									
Yes □	No □		15. Were any samples containers missing/excess (circle one) samples Not listed on COC?									
Yes □	No □	NA 🗆	16. Were bubbles present >"pea-size" ('4" or 6mm in diameter) in any VOA vials?									
Yes □	No □	NA 🗆	17. Were all DRO/metals/nutrient samples received at a pH of < 2?									
Yes □	No □	NA 🗆	18. Were all cyanide samples received at a pH > 12 and sulfide samples received at a pH > 9?									
Yes 🗆	No 🗆	NA 🗆	19. Were all applicable NH3/TKN/cyanide/phenol/BNA (< 0.5mg/L) samples free of residual chlorine?									
Yes □	No □	NA □	20. Were collection temperatures documented on the COC for NC samples?									
103 🗆	INO L	INA	21. Were client remarks/requests (i.e. requested dilutions, MS/MSD designations, etc)									
Yes □	No □	NA □	correctly transcribed from the COC into the comment section in LIMS?									
Yes □	No □		22. Was the quote number used taken from the container label?									
Sample F	Preservati	ion (M	ust be completed for any sample(s) incorrectly preserved or with headspace.)									
Sample(s)			were received incorrectly preserved and were adjusted accordingly in									
_	le receivii	ng with _	(H ₂ SO ₄ , HNO ₃ , HCl, NaOH) using SR #									
Sample(s)			were received with bubbles >6 mm in diameter.									
Samples(s			were received with TRC > 0.5 mg/L (If #21 is No) and were									
			ple receiving with sodium thiosulfate (Na ₂ S ₂ O ₃) with Shealy ID: Sample(s) pH verified to be < 2 by Date:									
Sample(s)	-		were Not received at a pH of < 2 and were adjusted accordingly using SR#									
	bels appl		Verified by: Date:									
	PP	J ·										
omments: _												

Shealy Environmental Services, Inc.

Page 53 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

8.4.4. Sample Storage

Samples must be stored appropriately to offer maximum preservation, to minimize contamination, and to maintain sample security within the laboratory.

All samples are stored in clean refrigeration units monitored and maintained at $4 \pm 2^{\circ}$ C. Volatile organic samples are stored separately from all other samples in matrix specific coolers and freezers. Inorganic non-metal samples are transferred from the sample receiving walk-in cooler to the inorganic non-metal laboratory walk-in cooler.

In the event of a catastrophic failure of our refrigerated storage facilities or an area-wide natural disaster that results in the loss of power, local truck rental companies will be contacted and a refrigerated truck will be rented to temporarily store samples until our internal system is functional.

8.4.4.1. Storage Blanks

To monitor potential volatile organic compound contamination of VOA samples, storage unit blanks are placed in dedicated refrigerators, sample storage freezers, and in the walk-in cooler every two weeks. One vial from each respective storage unit are analyzed for the TCL and UST list of compounds on the 13th or 14th day following storage. All storage unit blanks are logged into LIMS; the report is generated and reviewed by QA. Refer to the Deionized Water System and Storage Blank Testing SOP (ME0012S) for further details.

8.4.4.2. CLP Sample Storage

Samples that are received under the laboratory's CLP contract are stored in lockable refrigerated areas. All CLP Trace/SIM VOA (SOM) and low-level water samples are stored together in a lockable dedicated refrigerator in the VOA department. CLP low-medium solid samples are stored in a solid sample only refrigerator. All CLP semivolatile, pesticide, PCB, metals, and cyanide samples are stored in the walk-in cooler in the sample receiving department.

8.4.4.2.1. CLP Storage Blanks (Holding Blanks)

A storage blank associated with volatile organic samples is logged into the LIMS and prepared for each SDG. The Sample Receiving SOP (ME0013H) contains more details about the CLP Storage Blank procedure.

8.4.5. Internal Chain of Custody System

Shealy Environmental Services, Inc.

Page 54 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Security of samples and sample tracking is accomplished by an automated internal chain of custody program. When removing a sample from the sample receiving area, the bar code label attached to each sample container during the login process is scanned. The scanning process allows a record to be kept of the person who is taking the sample, the date taken, the analytical laboratory to which the sample is to be taken, and all other LIMS information previously entered for this sample.

Samples are required to be scanned from the sample receiving area to the department they are being transferred to. Samples are required to be scanned when being transferred between departments, and when and how they are disposed of.

8.4.6. Subcontracted Sample Transfer

EQI does not subcontract analytical work without written notification to our clients. When samples are subcontracted, a new chain of custody is issued to the subcontract laboratory with all pertinent information. EQI retains the original chain of custody and includes the new chain of custody with the project file.

8.4.7. Sample Return/Disposal

After preparation and analysis has been completed on a sample, it is returned to storage. Most samples are kept for a minimum duration of four (4) weeks before disposal. Others are kept longer due to client request. Sample extracts are retained for at least 40 days. Inorganic metal sample digestates are retained for 30 days. Exceptions to this include samples whose holding times are short and those that are consumed during analysis.

Regardless of the method of disposal or final disposition, EQI records the event through the internal chain of custody "bar code" system.

Sample containers are retained for SOM and ISM samples for 60 days following delivery of a complete, reconciled L4 data package. Extracts for SOM samples are kept for 365 days. TCLP/SPLP leachate and ISM digestates are kept for 180 days.

Samples are either returned to customers via the chain of custody system or disposed as either hazardous or non-hazardous waste. The Sample Receiving SOP (ME0013H) and the Hazardous and Non-hazardous Waste Management Plan (ME0012A) govern these activities. In the event samples are part of a litigation process, disposal of the samples shall only occur with the written approval of the legal authority, sample submitter, or sample data user.

8.5. Sustainability

Shealy Environmental Services, Inc. ("Shealy") is continuously evaluating methods and ways to become more sustainable. The following practices are in place at Shealy:

• Shealy purchases methylene chloride in bulk 200 liter containers which supply our solvent delivery system. Shealy has been using these bulk containers since 2002. Since the laboratory consumes approximately 18 bulk containers per year this saves 900 four liter glass containers, 225 cardboard shipping boxes, 450 foam box inserts, and reduces our overall carbon footprint as less deliveries are needed.

Shealy Environmental Services, Inc.

Page 55 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

 The laboratory has implemented organic extraction procedures that utilizes approximately six times less methylene chloride which further reduces our carbon footprint related to this solvent.

- Shealy participates in a chemical recycle/reuse program offered by our contracted waste
 disposal facility. Under this program, spent solvents are recycled into reusable products
 which are in turn utilized in industrial applications that do not require virgin products. This
 alternative to traditional solvent waste disposal minimizes the energy and resources spent
 making new chemicals and reduces the carbon footprint associated with traditional solvent
 waste treatment.
- Shealy continuously looks for ways to reduce hazardous waste generation through source reduction. This includes prudent management of chemical procurement to avoid overordering of chemicals and the use of micro-scale processes to reduce the volume of reagents used. These practices minimize the generation of hazardous wastes that may adversely affect the environment.
- The laboratory has been using gas generators since 2003 to produce zero air and hydrogen which reduces our carbon footprint since the delivery of compressed gas cylinders has been drastically reduced.
- Shealy installed a 3000 liter argon tank in 2001 which has eliminated the weekly delivery of argon dewars reducing our carbon footprint.
- Shealy installed a 700 liter nitrogen tank in 2015 which has eliminated the bi-weekly delivery of nitrogen cylinders and dewars reducing our carbon footprint.
- Shealy installed a white reflective membrane on the building roof in 2013. This highly reflective material has reduced our thermal heat load in the building resulting in a lower load on the air conditioning system. This has yielded optimal facility environmental conditions, and has resulted in less energy consumption by the chiller.
- Shealy installed a high-efficiency 80 ton chiller in 2014. This replaced the original chiller which was installed when the building was constructed in 1994. We have seen a 15% reduction in our kWh used since this unit was installed. This installation also qualified us for SCE&G's EnergyWise for Your Business Program.
- Shealy's field services department uses Toyota Tacoma trucks and Nissan NV200 mini cargo vans with 4 cylinder engines to perform sample courier services. These trucks are relatively environmental friendly with respect to emissions and fuel consumption.
- Shealy has been recycling office paper since 2000 and corrugated cardboard since 2011.
- Shealy has been systematically replacing fluorescent lights with LED lights and standard light switches with motion sensor switches.

Shealy Environmental Services, Inc.

Page 56 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

• Shealy continuously evolves our documentation processes from paper to electronic which has drastically reduced our paper usage. This is primarily driven through ongoing development of our laboratory information management system (LIMS) electronic notebooks.

9. Quality Systems

All laboratory activities must be closely planned, implemented, and controlled in order to meet both client and regulatory requirements. These activities are governed by the standard processes, practices, and procedures either detailed in or referenced by this QAMP. This section describes the processes, practices, and procedures that EQI utilizes to meet both client and regulatory requirements concerning environmental sample analysis.

9.1. Data Quality Objectives

Data Quality Objectives (DQOs) are used to ensure the quality of data produced when analyzing samples by established and practiced analytical methodologies. The EPA has established the following DQOs concerning environmental analyses:

9.1.1. Precision

Precision is a measure of the statistical variability of individual measurements of the same parameter under similar measurement conditions. The variability is caused by random or unpredictable error. Precision is expressed in terms of either relative standard deviation (RSD) for replicates involving more than two measurements, or relative percent difference (RPD) for duplicate measurements.

9.1.2. Accuracy

Accuracy is a measure of the agreement between a measured value and its true or expected value. The degree of accuracy reflects the presence and magnitude of systematic errors, or those errors of a consistent nature. Accuracy is expressed as percent recovery (% R).

9.1.3. Representativeness

Representativeness is the extent or degree to which a sample, or analytical data generated from a sample, represents a larger population. Representativeness relies on appropriate and precise sampling activities, as well as sample preparation that include the selection of a homogeneous aliquot of the sample.

9.1.4. Completeness

Completeness describes the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions. EQI utilizes, at a minimum, a completeness goal for data of 90 percent based on a total of all constituents analyzed.

Shealy Environmental Services, Inc.

Page 57 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.1.5. Comparability

Comparability is a measure of the confidence with which one data set can be compared to another data set. To ensure comparability, uniform procedures (SOPs) and practices must be used, as well as a uniform set of calculations and reporting units for analytical data.

9.1.6. Detectability

Detectability encompasses the establishment of instrument detection limits (IDLs), method detection limits (MDLs), the limit of detection (LOD), and the limit of quantitation (LOQ) for analysis methods.

9.1.6.1. Instrument Detection Limit (IDL)

EQI performs instrument detection limit studies (IDL Studies) studies for metals constituents on an annual basis. The IDL measurement is a direct measurement of instrument sensitivity. The IDL establishes the detection limit of the measurement instrument or measurement system under ideal conditions.

9.1.6.2. Detection Limit (DL)

The DL is the laboratory reporting limit, which must be greater than or equal to the MDL and below the LOQ and LOD. The DL is determined by the MDL. The DL must be equal to or higher than the calculated MDL and lower than the LOQ. The MDL is carefully evaluated to determine the DL. The DL must meet the following: $LOQ > LOD > DL \ge MDL$. The DL must be approved by the technical director, operations director, department group leader, and QA before being used for client reporting. The DL takes the place of the MDL in LIMs. Data reported below the LOQ, also known as a J value or estimated result, is reported to the DL.

9.1.6.3. Method Detection Limit (MDL)

The MDL is the minimum concentration of an analyte that, when a sample is processed through the complete method, produces a signal or result with a 99% probability that it is different from a blank. MDLs are determined by replicate analysis of prepared low-level standards. An MDL study is the process through which the laboratory determines a detection limit (DL) for a particular analytical method in adherence to requirements established in 40 CFR Part 136, Appendix B, Definition and Procedure for the Determination of the Method Detection Limit Revision 2.

9.1.6.3.1. **MDL Policy**

Shealy Environmental Services, Inc.

Page 58 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

EQI determines MDLs for all new methods or new compounds of interest for both aqueous and solid matrices. After the initial MDL is determined, verifications are performed quarterly, at the frequency specified by the method, or at the frequency specified by a program or contract (i.e. whenever a new instrument is brought on-line for CLP) whichever is more frequent. MDLs are generated for all individual analytes that can be spiked into a clean matrix. EQI performs an MDL study for a target analyte using each preparation method that will be used for client samples. MDL determinations are matrix-specific and *level-specific* (i.e., the MDL is determined for trace and trace SIM levels). MDLs must be less than any LOQ, RL, or CRQL (USEPA CLP) that may be reported to the client. Program and client specific MDL studies are performed as required. The Method Detection and Quantitation Limits Policy (ME001WR) outlines the procedures used in the determination of MDLs.

9.1.6.4. Limit of Detection (LOD)

The LOD is an estimate of the minimum amount of a substance that an analytical process can reliably detect. It is also defined as the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%. The LOD is analyte and matrix specific and may be laboratory dependent.

9.1.6.4.1. **LOD Policy**

EQI establishes limits of detection (LODs) for each analyte listed on the DOD Scope of Accreditation reported below the LOQ and are used to verify MDLs under the TNI standard, where applicable.

All LODs are supported by technical data such as MDL studies (see section 9.3.6.2.1.) and/or through the analysis of a standard at a concentration below the LOQ.

EQI's LODs are based on an evaluation of the laboratory's expected analytical performance. LODs are greater than the MDLs and in no case are LODs lower than established method detection limits. The Limit of Detection (LOD) Limit of Quantitation (LOQ) Determination and Verification Policy (ME001F1) outlines LOD determination and verification policies and procedures.

9.1.6.5. Limit of Quantitation (LOQ)

The LOQ is the minimum level, concentration, or quantity of a target analyte that can be reported with a specified degree of confidence. It is also defined as the lowest concentration that produces a quantitative result within specified limits of precision and bias. The LOQ shall be set at or above the concentration of the lowest initial calibration standard.

9.1.6.5.1. **LOQ Policy**

Shealy Environmental Services, Inc.

Page 59 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

EQI establishes LOQs for all reported analytes for which spiking solutions can be prepared. The LOQ is established as the concentration at or above the lowest initial calibration standard. All LOQs are supported by technical data such as MDL studies (see section 9.3.6.2.1.) or may be based on an evaluation of the laboratory's expected analytical performance. At the discretion of the technical director and the QAO, other technical data may be used such as a detection limit from a published method or a regulatory limit. LOQs are greater than the MDLs and in no case are LOQs lower than the established method detection limits. The Limit of Detection (LOD) Limit of Quantitation (LOQ) Determination and Verification Policy (ME001F1) outlines the LOQ determination and verification policies and procedures.

9.2. Quality Control

EQI uses various types of QC samples to generate data which confirms that the analysis is in control. QC sample data generated during analysis is used to satisfy the DQOs in section 9.3. QC samples include the following types:

9.2.1. Field QC Samples

This section describes the QC samples that EQI utilizes in both its field collection activities and its laboratory work. Field QC samples are collected during a field sampling event and are used to assess precision, accuracy and any possible contamination during collection, equipment cleaning and transfer of samples to the laboratory. EQI's Field Services Group Leader ensures that the proper type and number of field QC samples are collected during any field sampling activity performed. The laboratory considers field QC samples to be "routine" samples for the purposes of batching, sample preparation, analysis, and reporting of data. Analytical data is not adjusted based on the results of field QC samples.

9.2.1.1. Field Blank

A Field Blank (FB) is used to demonstrate the absence of contamination during sampling activities. It is normally comprised of contaminant free water or soil brought by the sampling crew to the site, and transferred to the proper sample container for shipment along with other collected samples. Field Blank sampling frequency is one sample per site per sampling day.

9.2.1.2. Rinsate Blank

A Rinsate Blank (RB), commonly called an "equipment blank", is used to demonstrate the effectiveness of field cleaning procedures for sampling equipment. A volume of rinse solution, usually contaminant free water, is sent through the cleaned sampling equipment in the same manner as a sample and collected for analysis. Rinsate Blank sampling frequency is generally one sample per site per sampling day when equipment is cleaned in the field.

9.2.1.3. Trip Blank

Shealy Environmental Services, Inc.

Page 60 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Volatile organic samples are susceptible to contamination by introduction or migration of contaminants through the volatile vial septum. A Trip Blank (TB) is utilized to detect possible volatile organic contamination of samples to be analyzed for volatile compounds. Trip Blanks are prepared by filling volatile sampling vials with deionized water. Trip Blanks accompany volatile sample collection vials to the sampling site, back to the laboratory, and are stored with the collected samples before analysis. Trip Blanks are supplied when requested for each cooler transported to a client or field site at the rate of 1 per shipping container.

9.2.1.4. Field Duplicate

A Field Duplicate (FD) is utilized to assess sampling precision. They are replicate samples taken for the same sampling event from a given sampling point or source. Frequency of the Field Duplicate collection is at the direction of the client.

9.2.1.5. Split Samples

A Split Sample (SS) is a sample that is collected and immediately divided into two parts. One portion is returned to the laboratory for analysis while the other is shipped to a second laboratory for identical analysis. Split Samples are used to gauge accuracy. Split Sample frequency is dependent upon a client's requirement.

9.2.2. Laboratory QC Samples

Laboratory QC samples are utilized to gauge the precision and accuracy of the analytical processes as well as to determine the effect of matrix or site/field conditions on the analytical data.

To ensure that the analytical process from sample preparation through data generation and evaluation is operating within acceptable QC guidelines, the laboratory performs a variety of QC checks. It must be noted that not all methods employ the use of all of the following QC elements. Detailed analytical SOPs contain the specific QC requirement. The following is a description of QC sample types and techniques.

9.2.2.1. Sample Batch

9.2.2.1.1. **Preparation Batch**

A preparation batch is composed of 1 to 20 environmental samples of the same matrix which are prepped together as a group. The maximum time between the start of processing the first and last sample in the batch is 24 hours. The samples must be processed by the same analyst(s) using the same lot(s) of reagents.

In general, the minimum QC requirements for each preparation batch are:

- One (1) method blank (MB)
- One (1) laboratory control sample (LCS)
- One (1) matrix spike (MS)

Shealy Environmental Services, Inc.

Page 61 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

• One (1) matrix spike duplicate (MSD)

Field QC samples, such as trip blanks, equipment blanks, and duplicate samples are considered individual samples and are included in the preparation batch size of no more than 20. Samples that require re-extraction or redigestion and analysis are considered additional samples and must be included as part of a new batch. Dilutions are not to be considered as part of the maximum 20 samples in a QC batch

Batch precision can be demonstrated through the analysis of a matrix spike and a matrix spike duplicate. Batch precision can also be demonstrated through the analysis of samples in duplicate. It should be noted that sample duplicates may not provide usable precision data if concentrations are below LOQs. A Laboratory Control Sample Duplicate (LCSD) may also be used as a measure of batch precision when insufficient sample exists to prepare a matrix spike, matrix spike duplicate, or a sample duplicate.

Precision over time is monitored via control charting of Laboratory Control Sample (LCS) values. A control chart is a graphical representation of analytical accuracy. It displays the arithmetic mean of a data set, the upper and lower warning limits, and the upper and lower control limits.

9.2.2.1.2. Analytical Batch

An analytical batch is composed of prepared environmental samples (extracts, digestates, or concentrates) which are analyzed together as a group (i.e. metals and SVOCs). An analytical batch may include prepared samples originating from various matrices.

Analytical methods that do not require an extraction or a digestion process, such as volatile organic analysis by purge and trap, require that the analytical batch is analyzed sequentially using the same instrument. The same calibration curve and calibration factors must be maintained for the entire batch.

9.2.2.1.3. **Batch Identification**

The identity of each sample batch is unique, documented and traceable.

9.2.2.2. Method Blank

A Method Blank (MB) normally consists of a volume of reagent water, Ottawa sand, sodium sulfate, glass beads or other preparation matrix that is processed as a normal sample. The MB must be carried through all the steps of the analysis being performed, such as cleanup, extraction, reagent addition, filtering, and analysis. A MB is used to detect interferences or contamination that may produce high or false positive data. One MB is prepared for each analytical batch.

Shealy Environmental Services, Inc.

Page 62 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.2.2.3. Initial Calibration Verification

The Initial Calibration Verification (ICV) is a standard prepared from a different source than the initial calibration standards. The ICV is analyzed after the initial calibration and is used to verify the accuracy of the calibration.

9.2.2.4. Initial Calibration Blank

An Initial Calibration Blank (ICB) is analyzed after the calibration in order to check system cleanliness before sample analysis. The ICB consists of reagent water (or other appropriate matrix) containing all reagents specific to the method which is carried through the entire analytical procedure.

9.2.2.5. Instrument Blank / Continuing Calibration Blank

An Instrument Blank (IB) consists of an aliquot of reagent, usually the same as used for sample dilution, processed through an instrument. An Instrument Blank measures the presence of possible contamination that may produce high or false positive data. An IB is also referred to as a Continuing Calibration Blank (CCB).

9.2.2.6. Continuing Calibration Verification

The Continuing Calibration Verification (CCV) is a standard that is prepared from the same source as the ICAL, usually at a concentration approximately at the mid-point of the ICAL. It is run at the beginning of the analytical day, at the end, and at intervals throughout the sequence to verify that the system is in control. The CCV is used as a continuing verification of the accuracy of the calibration.

9.2.2.7. Laboratory Control Sample / Laboratory Control Sample Duplicate

A Laboratory Control Sample (LCS) is a clean matrix sample to which known concentrations of target analytes are added (i.e. "spiked"). One laboratory control sample is analyzed with each analytical batch and is used to monitor the accuracy of the analytical process. Long term collection of LCS data is also used to gauge precision. A Laboratory Control Sample Duplicate (LCSD) may also be used as a measure of batch precision when insufficient sample exists to prepare a matrix spike, matrix spike duplicate or a sample duplicate.

9.2.2.8. Sample Duplicate

A Sample Duplicate (SD) is a second aliquot of a sample that is processed along with the sample. An SD is processed identically as independent samples within the same batch. SD results indicate the precision of the analytical process and may indicate a sample is homogenous in nature. An SD is randomly selected, pending sufficient sample volume or by client request.

9.2.2.9. Matrix Spike

Shealy Environmental Services, Inc.

Page 63 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

A Matrix Spike (MS) is a second aliquot of a sample to which known concentrations of target analytes are added. The addition of the analytes is performed prior to sample preparation or extraction. An MS is randomly selected, pending sufficient sample volume or by client request. The MS result, as compared to the unspiked sample, is used to evaluate the effect of the sample matrix on the analytical process, or the accuracy of analysis. Due to the variability of sample matrices, it is not typically indicative of other samples in the batch. In general, an MS is added to each batch, with the exception of some inorganic analyses.

9.2.2.10. Matrix Spike Duplicate

A Matrix Spike Duplicate (MSD) is a third aliquot of the same sample used for an MS, to which the same known concentrations of target analytes are added. The MSD is processed in the same batch as the original sample and the MS sample. The MS and the MSD results are used to determine the effect of the sample matrix on the precision and accuracy of the analytical process.

9.2.2.11. Post Digestion Spike

A Post Digestion Spike (PDS) is prepared by taking a digested sample aliquot and adding target analytes before analysis. It is useful in providing information on matrix interferences during analysis as compared to a predigested spiked sample. A PDS is most often employed in metals analysis.

9.2.2.12. Internal Standard

An Internal Standard (IS) is a chemical compound(s) or element(s) with properties that are similar in character and behavior to analytes of concern in an environmental sample.

Internal standards are normally added after sample preparation and are used to quantify the effectiveness of the measuring system, or gauge its accuracy. The IS can also be used to gauge short-term system performance or precision.

9.2.2.12.1. Two different types of internal standard are used in the preparation and analysis of PFAS. The Injection Internal Standard is an internal standard which is added to samples, QC, blank and standards just prior to analysis. The Extracted Internal Standard is an internal standard which is added to samples, QC, blank and standards prior to extraction.

9.2.2.13. Surrogate Standard

A Surrogate Standard is an organic compound(s) that behaves like the target analyte compounds, but is not normally investigated through analysis. Surrogates are added to all appropriate environmental samples and QC samples prior to preparation or analysis to determine matrix effects, preparation efficiencies, and the accuracy of the measurement system.

9.2.2.14. Interference Check Samples

Shealy Environmental Services, Inc.

Page 64 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

An Interference Check Sample (ICS) is a sample that contains known amounts of analytes that may cause interference during metals analysis. The ICS is useful in verifying background and interelement correction factors.

9.2.2.15. Post Serial Dilution Spike / Post Spike Sample

A Post Serial Dilution Spike or Post Spike Sample is a sample which is spiked at the LOQ in the final dilution reported. This only applies to aqueous PFAS samples prepared by serial dilution instead of SPE that have reported value of < LOQ for analytes.

9.3. Calibration of Equipment

9.3.1. Calibration Procedures

Equipment and instruments that are used for quantitative measurements are calibrated in accordance with established SOP procedures. The procedures provide the following information:

- Instrument(s) to be calibrated
- Standards to be used in calibration
- Calibration technique such as linear, response factor, etc.
- Calibration tolerances
- Corrective action if calibration tolerances are not met
- Frequency of calibration
- Documentation requirements

9.3.2. Periodic Verification of Support Equipment

Certain pieces of laboratory equipment require periodic verification at intervals as prescribed in the corresponding SOPs and/or Policies. Periodic verification generally applies to equipment having a singular purpose, and which is stable in performance. Equipment requiring periodic verification includes: analytical balances, top-loading balances, bottletop dispensers, micropipettes, IR thermometers used in sample receiving, fume hoods, Geiger counters and the thermometers used in freezers, coolers, water baths, and other similar equipment. Standards used for periodic verifications include NIST-certified weights for balance verification and NIST-certified thermometers for the verification of working thermometers. Some periodic verifications are performed by outside vendors such as balance verifications and the verification of Geiger counters.

9.3.3. Operational Calibration

Shealy Environmental Services, Inc.

Page 65 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Operational calibration is performed on a routine basis while using a measurement instrument or system. The calibration is directed by detailed requirements in method specific SOPs. Measurement instruments or systems which cannot pass initial calibration or fail ongoing calibration checks are taken out of service until they are repaired and a successful calibration is achieved.

9.3.3.1. Operational Calibration Verification

For all applicable analyses, an independent second source standard is used to verify instrument calibration. This second source standard is obtained or prepared from a source independent of that of the standards used for the initial calibration. That is, two standards either supplied by two different vendors or of differing lots from the same vendor, composed of the same target constituents, are used in order to ensure proper initial calibration. This second source is referred to as the initial calibration verification (ICV). Detailed requirements for initial calibration and ICV criteria are contained in method specific SOPs.

9.3.4. Calibration Records

All calibrations, whether periodic or operational, are documented and are retained per the quality record procedures outlined in the SOPs and/or Policies corresponding to the equipment.

9.4. Uncertainty Measurements for Results

All results have an inherent risk of uncertainty. When this uncertainty is due to measurable factors such as allowable variances due to prep (QC limits), allowable calibration variances (CCV limits), and/or equipment capabilities (smallest measurable increment), a statement can be made about the uncertainty of the result. Any tolerances should be applied to the results when assessing accuracy of data.

Each analytical SOP contains sections that list, wherever applicable, the established range of acceptable limits for QC such as the LCS and the MS. The LCS has in-house limits; these limits can be applied to the uncertainty of the result. The same is true for the calibration. If the calibration is allowed to drift 10%, the result could also reflect the same amount of drift.

Example: The LCS limits are established at 73-132% and the CCV is allowed a 90-110% window. The results could have a negative bias of 37% (27% + 10%) or a positive bias of 42% (32% + 10%) in the worst case scenario. Thus, a known standard of 100 mg/L could read in the range of 63 mg/L - 142 mg/L. This same amount of uncertainty could apply to all samples in the batch.

Example: An MS can be biased due to the matrix of the sample. If an MS recovery is 99%, and the CCV was allowed 90-110%, the results could have a negative bias of 11% (1% + 10%) or a positive bias of 9% (10% - 1%). A very low recovery would show a major bias and the data associated should be scrutinized by the end user. This type of bias applies only to the sample associated with the MS.

Shealy Environmental Services, Inc.

Page 66 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

For tests that do not use conventional QC limits, other factors may apply. Many tests calculate the uncertainty from the smallest increment that is measurable. A titration can be calculated with an uncertainty that is equal to the smallest increment on the burette times the calculation used for that particular method. The burette for manual sulfide titration has 0.1 mL increments. This calculates to be 0.2 mg/L of sulfide. Therefore, any measurement has an uncertainty of 0.2 mg/L.

9.5. Standards and Reagents

9.5.1. Standards

Standards are materials containing a precisely known concentration of a substance for use in quantitative analysis. All standards used at EQI are supplied by approved vendors who can supply a certificate of analysis. All standards must be traceable to NIST, ASTM, ISO Guide 34 or equivalent where applicable. A more detailed procedure for the purchasing of standards can be found in the Procurement of Laboratory Supplies, Services and Equipment SOP (ME0015U).

All chemical reference standards used in calibration or in the preparation of spiked samples are prepared, documented, labeled and stored according to the analytical SOP and the Preparation and Documentation of Laboratory Standards and Reagents SOP (ME001HG).

9.5.2. Reagents

Reagents used in the preparation and/or analysis of samples are also required to be supplied by approved vendors who can certify the purity. Many analyses are performed at trace levels, therefore only reagents of the appropriate purity level are purchased. A more detailed procedure for the purchasing of reagents can be found in the Procurement of Laboratory Supplies, Services and Equipment SOP (ME0015U).

All reagents are prepared, documented, labeled and stored according to the analytical SOP and the Preparation and Documentation of Laboratory Standards and Reagents SOP (ME001HG).

9.5.3. Traceability

All standards are purchased from vendors who must document the quality of the materials they sell through certificates verifying NIST traceability, when available.

At receipt, all standards are given a unique identifying number (i.e. "EQI (Shealy) ID") and the following is documented at a minimum:

- Lot number
- Receipt date
- Manufacturer
- Catalogue (part) number
- Expiration date

Shealy Environmental Services, Inc.

Page 67 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

A more detailed procedure for ensuring traceability of standards can be found in the Procurement of Laboratory Supplies, Services and Equipment SOP (ME0015U). Refer to the Preparation and Documentation of Laboratory Standards and Reagents SOP (ME001HG) for specific procedural guidance on standard preparation and documentation.

9.6. Data Recording

9.6.1. Recording Policies

To ensure data completeness and integrity, EQI adheres to data recording policies which govern the requirements for proper documentation of data and records. These policies are found in the Logbook and Data Recording SOP (ME0012T).

9.6.2. Rounding and Significant Figures

All analytical data must be reported in a consistent manner that reflects a standard method for rounding and establishing significant figures. The following policies have been established to ensure the proper handling and reporting of data with respect to rounding and the use of significant figures.

- LOQs must be expressed with the identical number of significant figures as the data to be reported.
- LOQs that are altered by calculation (dry weight or dilution factors) are rounded per the same rules as apply to analytical data, to yield the identical number of significant figures as the final data reported.
- Data must be rounded before comparison to the LOQ to determine if the result is a reportable number or should be reported as less than the LOQ or non-detect (ND).
- Data must be rounded before comparison to a control limit to determine acceptability.
- Software used to perform calculations must comply with the rounding rules of this policy.
- Data entry into the LIMS, where calculations may be made, requires the input of the maximum number of digits available from the analysis.

9.6.3. Rounding Rules

• When the digit that immediately follows the one to be retained is less than five (5), the one to be retained stays the same (round down).

Example 1	8.54 = 8.5	round down
Example 2	3.8499 = 3.8	round down

• When the digit that immediately follows the one to be retained is greater than or equal to five (5), the one to be retained is increased by one (1).

Shealy Environmental Services, Inc.

Page 68 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Example 1	7.76 = 7.8	round up
Example 2	4.6877 = 4.7	round up
Example 3	4.85 = 4.9	round up
Example 4	6.75 = 6.8	round up
Example 5	2.5501 = 2.6	round up

Microbiology results are rounded up to the nearest whole number.

9.6.4. Significant Figure Rules

Data Type	Organic	Organic QC % Recovery	Inorganic	Inorganic QC %Recovery	RPD
Method Blank	2	NA	2 ^B	NA	NA
LCS/LCSD	3	A	3	A	A
MS/MSD	3	A	3	A	A
Duplicates	2	NA	2	NA	A
Surrogates	3	A	NA	NA	NA
Sample Results	2	NA	2^{B}	NA	NA

A 2 Significant figures if value is < 100

9.7. Data Review

All data generated by the EQI laboratory receives three (3) independent levels of review, each of varying comprehension and intensity. The three levels are:

- Data Reduction and Primary Verification (Level I)
- Secondary Verification (Level II)
- Verification of Completeness (Level III)

The review process is flow charted below.

³ Significant figures if value is ≥ 100

^B For inorganic non-metals, significant figures will vary from method to method.

Shealy Environmental Services, Inc. Document Number: ME0012K-06

Page 69 of 100 Effective Date: 7/13/2018

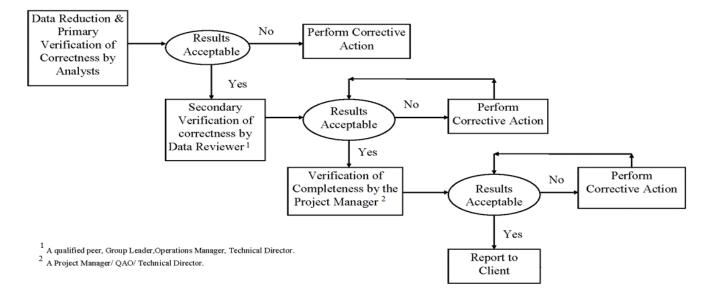


Figure 9.7.1 Data Review Process

Data is normally processed by an analyst in one of three ways:

- Manual computation of data/results in a logbook or on a batch sheet which is then entered into LIMS.
- Automatic transfer of data to LIMS via instrument or interim software. Data processing may occur
 prior to or completed in LIMs following transfer.
- Data entry into a spreadsheet where it is processed followed by entry into LIMS.

If data is processed by manual computation via the use of a spreadsheet, the analyst must provide all computation information including, but not limited to, the source of input parameters such as response factors, dilution factors, and calibration constants. If data is entered by an analyst and processed by a computer in a spreadsheet, the input must be saved and identified. If data is subsequently transferred to LIMS, the analyst must verify that all necessary information is entered correctly.

9.7.1. Data Reduction and Primary Verification (Level I Review)

Data reduction and primary verification of the data is executed by the analysts' performing the preparation and analysis. The data reduction and primary verification must ensure the following:

- Sample preparation information is complete and accurate and includes documentation of standards, solvent lot numbers, sample volume, and other key data as required by SOPs / Policies.
- Analytical information is complete and accurate including the proper identification of the analytical output such as chromatograms, charts, printouts and etc.
- Analytical results are complete and accurate including instrument calibration, verification, batch and / or instrument QC data and etc.

Shealy Environmental Services, Inc.

Page 70 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- The appropriate methods / SOPs have been used.
- Proper documentation procedures have been used.
- All nonconformances have been documented, with a properly completed NCM.
- The data generated has been recorded with the appropriate number of significant figures.

Initial data reduction and primary verification is documented in at least one of three ways:

- On a data review checklist, which is initialed and dated by the analyst.
- In LIMS with the analyst initials.
- In a logbook, spreadsheet, or on a batch sheet with the analyst initials and date.

9.7.2. Secondary Verification (Level II Review)

Upon the completion of data reduction and primary verification by the analyst, a second level of verification is performed. This secondary verification is performed by a peer, a Group Leader, a Data Specialist, the Operations Director, or the Technical Director.

This secondary verification includes the re-examination of all data reviewed and signed by the analyst, with emphasis on exceptions noted. Included in this review is an assessment as to the acceptability of data as per the following:

- Analytical procedure performed is the procedure requested.
- Adherence to the required SOPs.
- Correct interpretation of outputs such as chromatograms.
- Correctness of data before it is transferred into LIMS.
- Correct identification of constituents.
- Correct quantification of constituents
- Random check of 10% of all calculations for non-automated analyses.
- Review of data to ensure acceptability of calibrations, performance checks and etc.
- Acceptability of QC data.
- Review of data concerning standard concentrations and dilution factors.
- Sample holding time compliance.
- Nonconformance events have been addressed and corrective action, if appropriate, has been taken and documented on a properly completed NCM.
- Interpretations by the analyst are correct, as are any data review comments.

Secondary verification is documented in at least one of four ways:

- Reviewer's initials and date on the data review checklist as secondary reviewer
- Reviewer's initials in LIMS as secondary reviewer.
- Reviewer's initials and date in spreadsheet as secondary reviewer.
- Inorganic Non-metals manual entry: double entry analyst's initials in LIMS as secondary reviewer.

9.7.3. Verification of Completeness (Level III Review)

Shealy Environmental Services, Inc.

Page 71 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

A third level review to verify the completeness of the data reported and the L3/L4 data package (if applicable) is required before results are submitted to clients. This final review is conducted by the project manager.

The items reviewed during this third and final verification are as follows:

- Analytical results are included for all samples analyzed.
- Every parameter or requested analyte is reported with a value or a limit.
- The proper reporting format is used.
- All appropriate preparation and analysis dates are identified as are the initials of the analyst.
- All nonconformances such as holding time violations and data evaluation qualifiers are clearly expressed.
- The final report package is per the EQI or the client specified format and contains all the required supporting documentation. The final review is documented by the reviewer by signing the final printed report.

9.7.4. Data Package Review (Level IV Review) (where applicable)

A fourth level of review to verify that the L3/L4 data package contains all of the appropriate forms, summaries and data required and that all items are in the correct order is required before submitting a L3/L4 data package to the client. This review is conducted by a data package specialist. See the Data Package Generation, Assembly and Review Policy (ME001QX) or the CLP Data Package Generation, Assembly and Review Policy (ME0013C) for further details.

9.8. Data Evaluation and Corrective Action

The following sections detail the guidelines used for evaluation of QC samples and corrective action. QC acceptance criteria are outlined in section 9.8.9.

9.8.1. General Policy

Any measure of QC that fails to fall within established limits is considered a QC failure. QC failures must be documented and all associated data evaluated to determine an appropriate plan of correction. As it is impossible to address all data evaluation circumstances, EQI's guiding principal is to use established policies and procedures, along with good scientific evidence and judgment, to make sound data evaluations. When a QC failure occurs and a reanalysis and/or re-preparation indicates that the cause is not within the laboratory's control, no additional corrective action is required. The issue must be documented in the final report. When a QC failure occurs, it must be recorded as a nonconformance event. Sample matrix interferences are normally outside of the laboratory's control as they are a function of the method utilized. Therefore, failures due to matrix affect are documented in the final report.

When systematic failures are identified, all analysis must cease until the problem is identified and control is restored. System nonconformances are addressed in section 10.1.4.

9.8.2. Method Blank (MB) Evaluation

Shealy Environmental Services, Inc.

Page 72 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.8.2.1. MB Acceptance Criteria for Data Reported to the LOQ

All analyte concentrations in the MB must be less than the LOQ or project specific reporting limits with the following exceptions:

- Samples in the batch show no detection of a contaminant found in the MB.
- The contaminant is not a target compound for samples in the batch.
- The analyte concentration in the samples is greater than 10 times the MB concentration (may be greater than 20 times the MB as per analytical SOP).
- If a MB contamination occurs and insufficient sample exists for re-extraction or reanalysis, any contaminant detections in the associated samples are flagged with a "B" on the final report.

9.8.2.1.1. MB Corrective Action (LOQ)

The general corrective action requirement is to first reanalyze the MB, if the analytical SOP allows. If MB contamination is confirmed then the entire batch must be reprepared / reanalyzed.

9.8.2.2. MB Acceptance Criteria for Data Reported to the MDL / LOD

For a method blank to be acceptable for use with the associated samples, the concentration of analytes detected in the blank must be \leq LOQ or project specific reporting limits, unless specified by the method. The following exceptions apply:

• For DoD and NC samples, analytes in method blanks must be < 1/2 LOQ.

9.8.2.2.1. MB Corrective Action (MDL / LOD)

If the MB does not meet the criteria above, the source of the contamination must be investigated and measures taken to minimize or eliminate the problem. The affected samples must be reprepared / reanalyzed or the data must be appropriately qualified. All steps taken to return the system to control must be fully documented. If reprep / reanalysis is not possible due to limited sample volume or holding time, then the samples associated with the contaminated blank must be appropriately qualified.

A flowchart, which diagrams the evaluation of the MB, is located in Figure 9.8-1.

Effective Date: 7/13/2018

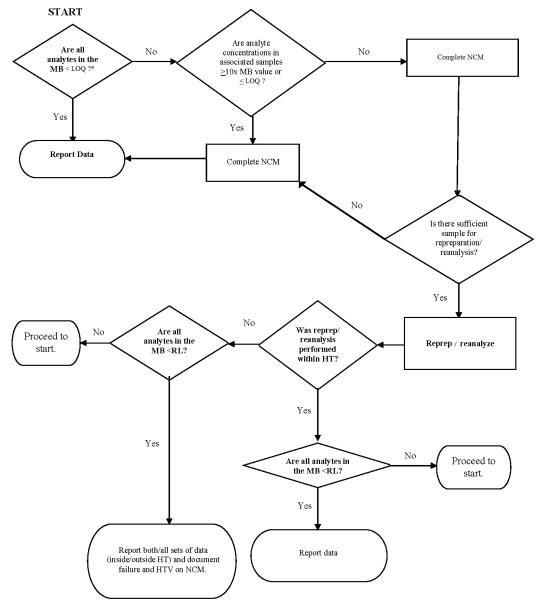


Figure 9.8-1 MB Evaluation

*Unless otherwise specified by the method. For DoD and NC samples, analytes in Method Blanks must be \leq 1/2 LOQ.

Shealy Environmental Services, Inc. Document Number: ME0012K-06

Page 74 of 100 Effective Date: 7/13/2018

9.8.3. Laboratory Control Sample (LCS) Evaluation

9.8.3.1. Accuracy Expressed as LCS (or LCSD) % Recovery

% Recovery =
$$\frac{X}{t}$$
x 100

Where:

X = observed concentration of spiked sample t = actual concentration of spike added

9.8.3.2. LCS Acceptance Criteria

Laboratory Control Sample percent recovery must be within established limits. The following is an exception to LCS/LCSD acceptance criteria:

If the LCS recovery is greater than control limits and the sample results are <
LOQ, the batch may be accepted for some but not all regulatory agencies.
 Specific regulatory agency or program requirements are found in the analytical SOPs.

9.8.3.3. LCS Corrective Action

The general corrective action requirement is to check all calculations, check the instrument performance, and reanalyze the LCS when the method/SOP allows. Where subsequent samples are associated with the failed LCS, or if the reanalyzed LCS recovery limits are still outside of control limits then the entire batch must be reprepared and reanalyzed.

9.8.4. Laboratory Control Sample Duplicate (LCSD) Evaluation

9.8.4.1. Precision Expressed as LCS / LCSD RSD / RPD

9.8.4.1.1. **Relative Standard Deviation (RSD)**

$$\% RSD = \frac{SD}{X} \times 100$$

Where:

X = Mean of all measurements SD = Standard deviation of all measurements

SD =
$$\sqrt{\sum_{i=1}^{N} \frac{(x_i - \bar{x})^2}{N-1}}$$

Xi = Individual measurementN = Number measurements Shealy Environmental Services, Inc.

Page 75 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.8.4.1.2. Relative Percent Difference (RPD)

RPD =
$$\frac{|X1 - X2|}{\frac{(X1 + X2)}{2}} \times 100$$

Where:

X1 = first observed concentration X2 = second observed concentration

9.8.4.2. LCSD Acceptance Criteria

The Laboratory Control Sample Duplicate percent recovery must be within established limits. In order to maintain consistency for batches containing samples from more than one client, where one requires a single LCS and a second requires an LCSD, the first spike of the pair must be reported as the LCS. The precision for the pair must be within established limits.

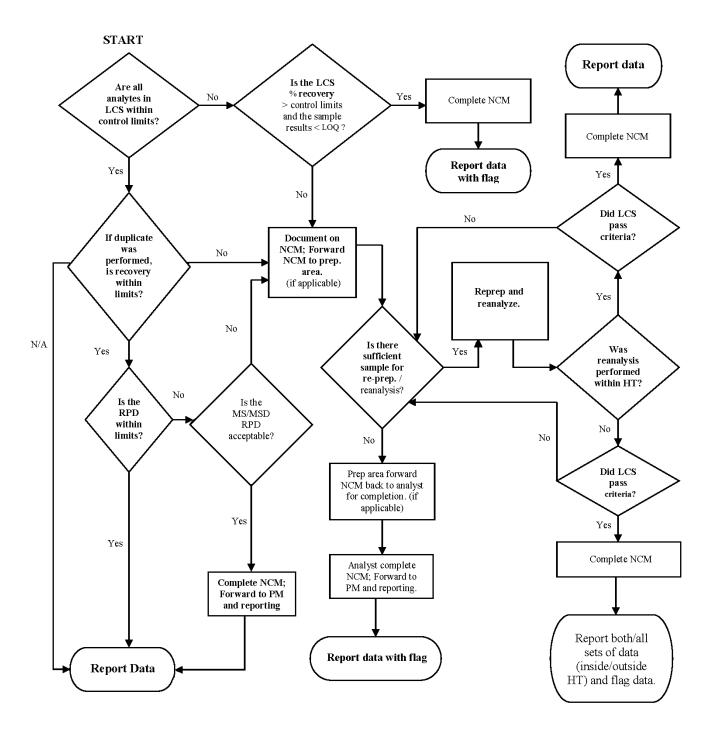
9.8.4.3. LCSD Corrective Action

Check all calculations and instrument performance. If necessary, reanalyze the control sample and if it is still out of limits, re-prepare and reanalyze all samples in the QC batch. If either the LCS or the LCSD fails and the batch cannot be reanalyzed, the failure is noted and documented.

A flowchart, which diagrams the evaluation of the LCS/LCSD, is located in Figure 9.8-2.

Effective Date: 7/13/2018

Figure 9.8-2 LCS / LCSD Evaluation



Shealy Environmental Services, Inc.

Page 77 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.8.5. Surrogate Evaluation

9.8.5.1. Surrogate Acceptance Criteria

All batch QC such as the MB, LCS, and LCSD must have acceptable surrogate % recoveries. If any batch QC does not have acceptable surrogate recoveries, the same corrective action described for each QC sample must be followed. If field samples or MS/MSD samples require dilutions greater than or equal to 5X due to elevated target and/or non-target analytes, the surrogate acceptance limits do not apply with the exception of aqueous and non-aqueous liquid VOC analysis. Additionally, if objective evidence of matrix interference exists re-analysis and/or re-extraction may not be required. An NCM must be completed documenting this situation.

A flowchart, which diagrams surrogate evaluation, is located in Figure 9.8-3.

Report both sets

of data (inside and

outside HT) with

flag.

Complete NCM

Report data with flag.

due to demonstrated

matrix effect".

"Surrogates failed

Complete NCM

Document Number: ME0012K-06 Effective Date: 7/13/2018

START Do MB, LCS/LCSD Is the surrogate No No recovery high Complete NCM recoveries and samples meet criteria? < LOQ ? Yes Complete NCM Yes No Is there sufficient sample for reprep? Do Is there sample, MS/MSD Is dilution > No objective threshold in evidence of Yes surrogate SOP? No matrix recoveries interference? meet? Yes Yes Yes Reprep and reanalyze. Complete NCM Complete NCM Report data with Report data with flag. Was reanalysis Yes No flag. performed within HT? Report data. Are surrogate Are surrogate recoveries within recoveries within Complete NCM acceptance acceptance Yes limits? limits? No Report data. Yes

Figure 9.8-3 Surrogate Evaluation

Shealy Environmental Services, Inc.

Page 79 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.8.6. Matrix Spike and Matrix Spike Duplicate (MS/MSD) Evaluation

9.8.6.1. Accuracy Expressed as MS % Recovery

% Recovery =
$$\frac{X_s - X}{t} \times 100$$

Where:

Xs = observed concentration in spiked sample (MS) X = observed concentration in unspiked sample t = actual concentration of spike added

9.8.6.2. Precision Expressed as MS / MSD RSD / RPD

See section 9.8.4.1 for RSD and RPD calculations.

9.8.6.3. MS / MSD Acceptance Criteria

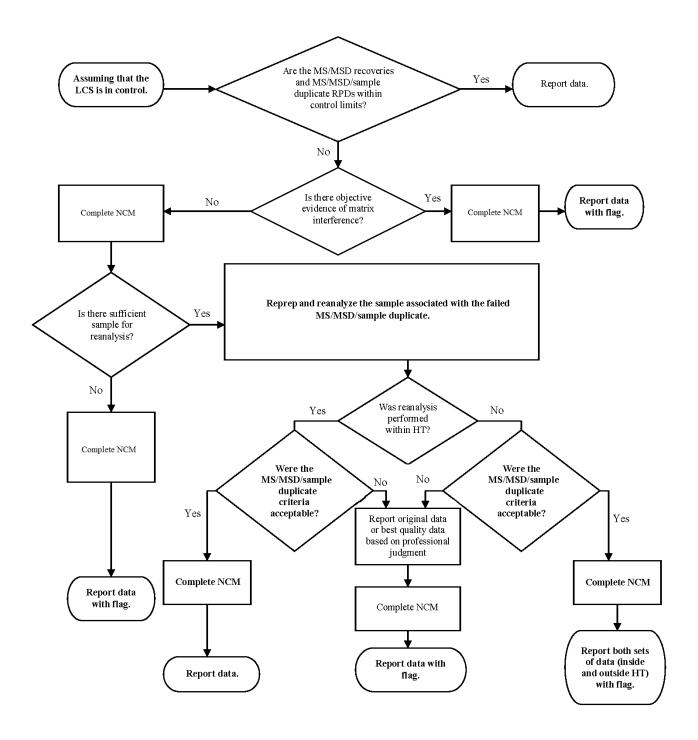
MS and MSD percent recoveries and relative percent differences between MS and MSD recoveries must be within established limits. If MS and MSD samples require dilutions above the limits stated in analytical SOPs, control limits do not apply.

9.8.6.4. MS / MSD Corrective Action

If the LCS is in control, check all calculations and instrument performance. Determine if objective evidence of matrix interference is present such as non-homogeneous sample or interfering compounds as seen on chromatograms. The failure must be documented and noted on the final report.

A flowchart, which diagrams the evaluation of the MS/MSD, is located in Figure 9.8-4.

Figure 9.8-4 MS / MSD Evaluation



Shealy Environmental Services, Inc.

Page 81 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

9.8.7. Sample Duplicate Evaluation

9.8.7.1. Precision Expressed as Sample Duplicate RPD

See section 9.8.4.1 for the RPD calculation.

9.8.7.2. Sample Duplicate Acceptance Criteria

The RPD for the sample and its duplicate must be within established limits.

9.8.7.3. Corrective Action

Check all calculations and instrument performance. The failure must be documented and noted on the final report.

9.8.8. Internal Standards

9.8.8.1. Internal Standard Acceptance Criteria

As defined in the appropriate analytical SOP.

9.8.8.2. Internal Standard Corrective Action

Reanalysis of sample or extract.

9.8.9. QC Acceptance Criteria

For all analyses, QC acceptance criteria are found in the analytical SOPs and have been derived either from the published method, regulatory agencies or programs or from laboratory derived limits. For all organic analyses, where allowed by regulators, QC acceptance criteria may be statistically derived using a minimum of 20 data points.

Regulatory agency, program or client specific acceptance limits are often used rather than inhouse and/or method derived limits. These specific limits are contained in the LIMS database. Program specific acceptance limits such as the DoD QSM may also be contained in analytical SOPs as appendices. Organic analysis QC acceptance criteria are determined by calculating mean and standard deviation values for the subject data per the following conventions (where s = standard deviation):

LCS or LCSD Accuracy: All methods: mean recovery ±3s Surrogates Accuracy: All methods: mean recovery ±3s

MS/MSD Accuracy: 8000 series methods: mean recovery ±3s

Inorganic parameters: mean recovery ±3s

MS/MSD and DU Precision: 8000 series methods: Zero to (mean RPD ±3s)

Other methods: Zero to (mean RPD $\pm 3s$)

Shealy Environmental Services, Inc.

Page 82 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

LCS/LCSD Precision: All methods: Zero to (mean RPD ±3s)

If there is insufficient MS/MSD data available to calculate limits, LCS/LCSD limits may be used. If there is insufficient sample surrogate recovery data available to calculate limits, method limits may be used.

Control limits are set after the laboratory statistical performance is calculated and compared to limits published in reference methods. Evaluation of the statistical calculations versus the published limits is accomplished by the following tables.

9.8.9.1. Accuracy Evaluation

Lower Limit Evaluation	Upper Limit Evaluation	Accuracy Decision
lab generated lower limit >	lab generated upper limit >	use lab generated lower limit
guidance limit	guidance limit	and guidance upper limit
lab generated lower limit >	lab generated upper limit <	use lab generated lower limit
guidance limit	guidance limit	and lab generated upper limit
lab generated lower limit <	lab generated upper limit >	Use guidance lower limit and
guidance limit	guidance limit	guidance upper limit
lab generated lower limit <	lab generated upper limit <	Use guidance lower limit and
guidance limit	guidance limit	lab generated upper limit

9.8.9.2. Precision Evaluation

Range Evaluation	Precision Decision
Lab generated precision > guidance precision value	Use guidance precision
Lab generated precision < guidance precision	Use lab generated precision

Notes:

- 1. Laboratory-generated range = calculated statistical range Published guidance range = (upper control limit – lower control limit)
- 2. If the decision leads to limits that are significantly tighter than both the guidance limits and the calibration acceptance criteria for the method, the laboratory can default to using the laboratory-generated mean + calibration acceptance limit. Unreasonably tight statistical limits can result from exclusion of outliers from the database.
- 3. If the decision is to use guidance limits from the method, the laboratory should investigate procedural improvements leading to better performance.

9.8.10. CLP QC Acceptance Criteria

Shealy Environmental Services, Inc.

Page 83 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

For analyses performed under the EPA CLP SOW, all acceptance criteria and corrective actions are found in the individual SOPs for the SOM analysis of organics and the ISM analysis of inorganics.

9.9. Reporting of Data

9.9.1. Analytical Results

Analytical results are reported per analytical SOP or the client's specifications. Results that are less than the LOQ are reported as a non-detect (ND) with the LOQ noted. Customized reporting formats are also available. A few examples are:

- If the lab is asked to report analytes of interest that are less than the LOQ but greater than the MDL, the data will be reported and flagged with an appropriate qualifier (J).
- If the lab is asked to report tentatively identified compounds (TICs) this data will be flagged with an appropriate qualifier.
- If a client specifies an LOQ in excess of the EQI limit, only those analytes found in excess of the client specified limit would be reported as positive values. All analytes of interest below the client specified limit would be reported as ND.

9.9.2. Verbal Results

EQI discourages the verbal release of both reviewed and un-reviewed analytical data. If a client requests verbal or hard copy results before final review, the results must be clearly identified as preliminary and are subject to change.

9.9.3. Report Format

EQI is capable of providing many report formats from relatively simple reports to "CLP like" L3/L4 data packages. We also offer other deliverables including electronic data transfer and a wide variety of electronic data deliverable (EDD) formats. EDDs can be customized based on client requirements.

9.9.4. Revisions to Reports

Any revision to a final report is documented via a Revision Notice form (ME001W6). This notice is sent to the client, along with the revised report. In addition, a copy of the revised report and the revision notice is filed with QA. Any revisions must be verified for completeness before re-sending.

9.9.5. USEPA CLP Report Organization, Preparation, and Review

Shealy Environmental Services, Inc.

Page 84 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Forms for reporting data for the USEPA CLP contract are generated via LIMS. Package assembly and final review are performed by data specialists and encompasses the use of multiple software platforms. The laboratory produces a contract compliant L4 data package that meets all specifications of the SOM and the ISM SOW. CLP package assembly and final review is more specifically outlined in the CLP Data Package Generation, Assembly and Review policy (ME0013C).

10. Quality Assessment and Improvement

Quality assessment and improvement tasks are consistently and programmatically performed throughout each year. Examples of these activities include nonconformance memo monitoring, corrective action / preventive action investigations, nonconforming item reports, internal and external audits, management review, client complaint investigations and client survey evaluation.

Quality improvement projects may be launched anytime there is a perceived need to make a change or modify conditions that may affect quality. Examples of quality improvement projects are quality or service improvement, customer satisfaction enhancement, productivity improvement, waste reduction, removal of obsolete documentation, safety enhancement, cost saving, cycle time reduction, and work flow streamlining. Management must play an important part in steering and supporting the effort to ensure that conditions adverse to quality are prevented, identified promptly, corrected promptly and that actions are taken toward prevention, documented and actions tracked to closure. EQI employees are encouraged to initiate the quality improvement process by submitting their ideas to his/her Group Leader or any member of management.

10.1. Nonconformance Events

Deviations from SOPs and Policies are documented in a nonconformance memo (NCM). Problems of various types and degrees of complexity are inherent in any analytical process. It is a major goal of the entire EQI organization to minimize the occurrence and potential severity of problems within our control, especially those that pose a threat to the generation of quality data. Resolutions to problem events or "nonconformance events" must be commensurate with the severity of the problem. In cases where a nonconformance event occurs, the problem and the solution are documented. EQI categorizes nonconformance events into the following four categories:

- Sample Receipt Nonconformance
- Quality Control Nonconformance
- Laboratory Nonconformance
- System Nonconformance

All types of nonconformance memos can and are used to identify trends in the analytical systems of the laboratory. When a trend is identified, a Corrective Action Preventive Action (CAPA) which includes an investigation into the root cause is initiated and solutions to the problem are implemented as needed. The NCM, CAPA and NIS procedures are outlined in the NCM, CAPA, Client Complaints and Nonconforming Items and Services SOP (ME001BO).

10.1.1. Sample Receipt Nonconformance

Shealy Environmental Services, Inc.

Page 85 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

As discussed previously in this document, all samples and documentation received with samples are rigorously reviewed during the sample receiving process to ensure and document the integrity of the sample collection, documentation, preservation, and shipping process. Sample receiving personnel document nonconformances at sample receipt on the Sample Receipt Checklist (SRC; ME0018C). Examples of this type may include such things as temperature exceedances, container breakage upon receipt, samples requiring further preservation, and/or chain of custody versus client label discrepancies.

10.1.2. Quality Control Nonconformance

Quality control nonconformances are documented through the generation of a properly completed nonconformance memo (NCM) during the first or second level of data review. A QC NCM is generated for any data reported outside method or SOP criteria but may still be of value to the end user. An example may include QC acceptance limits outside method criteria due to sample matrix. QC NCMs may also be reported on the final analytical report in the case narrative. The NCM application in the LIMS is used to generate NCMs which are automatically emailed to the appropriate employees as needed.

10.1.3. Laboratory Nonconformance

A laboratory nonconformance may result from an isolated incident or from any instance where the laboratory cannot follow documented policies, procedures, and/or standard specifications. Examples may include such things as insufficient sample volume or improper preservation, dilutions due to difficult sample matrices, or container breakage with subsequent sample loss.

It should also be noted that an NCM is also completed prior to the rare case where the laboratory cannot follow documented policies, procedures, and standard specifications. An example would include a client request for a deviation from the standard method procedure. The proper level of laboratory management will review any departure from documented policies and procedures. These departures will be permitted only with the approval of the Laboratory Director, Technical Director and/or the QAO. The NCM application in LIMS is also used to generate laboratory nonconformances.

10.1.4. System Nonconformance

A system nonconformance is a large and "non-isolated" deviation from stated policies, practices, and procedures. If uncorrected, a system nonconformance may result in a serious question as to the validity of a broad pool of data. A system nonconformance includes problems where stated practices are not followed and the ongoing malfunction of a measurement system without resolution. System nonconformances are documented with a corrective action and preventive action (CAPA).

10.1.5. Corrective and Preventive Action (CAPA)

Shealy Environmental Services, Inc.
Document Number: ME0012K-06

The Corrective and Preventative Action (CAPA) application in EQLIMS issued to document compliance issues associated with Internal and External Audits (where required), Proficiency Test failures, NCM trend investigations, system nonconformances or other quality-related issues. Corrective action investigations help to eliminate the root cause of nonconforming events in order to prevent recurrence. Preventive actions help to determine and eliminate the root cause of potential nonconformances in order to prevent occurrence. The EQLIMS CAPA app is also used to track all corrective and preventive actions to completion.

Page 86 of 100

Effective Date: 7/13/2018

10.1.6. Nonconforming Items and Services (NIS)

A Nonconforming Items and Services Report (ME0024Q) documents items or services purchased by EQI that do not meet EQI's quality requirements.

For example: a standard purchased by EQI that does not meet the criteria stated on the Certificate of Analysis. Although this is a rare nonconformance, the potential for high impact to the quality of data is significant. An investigation is performed and the impact on data quality is evaluated. A corrective action is formulated and implemented.

10.2. Quality Assessment Audits

10.2.1. Audit Types

Audits of the laboratory are performed to assess the degree of compliance to stated policies, practices, and procedures. These audits are conducted by external agencies such as certifying bodies and clients, as well as internally by EQI personnel. The following is a list of audits routinely performed, along with a brief description of purpose and frequency. See the Internal Audits and Data Report Review SOP (ME0015T) and the Performance Evaluation / Proficiency Testing SOP (ME001IG) for more details.

Shealy Environmental Services, Inc.

Page 87 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

AUDIT	TYPE	DESCRIPTION/ PURPOSE	FREQUENCY
Proficiency Testing (PT)	Internal & External	To verify the laboratory's ability to correctly identify and quantify compounds.	2 complete studies per year per program area
Data	External	Random selection of a final report in order to trace the overall process from sample receiving through data verification. Each step in the process is evaluated for proper documentation, evaluation, and verification of data.	External - Varies per assessing body.
Field	Internal	Random selection of a field sampling event to assess the overall process from equipment preparation through collection technique and sample delivery to the lab.	Internal – Annually External – Varies per assessing body
Procedural / Technical	Internal & External	Internal audits are performed by the QAO, QA Specialist, QA Associate and/or Operations Director. Checklists such as the DOECAP checklist may be utilized.	Internal - Annually all areas of the lab must be audited. External - Varies per assessing body.
Quality Systems	Internal & External	A comprehensive review of the overall quality system.	Internal - Annually External - Varies per assessing body.

10.2.2. Audit Responses

Audit deficiencies, whether identified by external or internal auditors, warrant an expeditious response and correction timetable. Response to external audits must adhere to the time frame specified by the auditor if possible/practical. If not possible/practical, negotiated time frames must be agreed upon. A plan of action to correct audit deficiencies, as well as corrective action taken, must be documented.

The QAO has the responsibility to coordinate all external audit responses. The development of corrective action for both external and internal audits and implementation of corrective action is the responsibility of the Operations Director, the Technical Director, the Group Leaders and their staff. It is the responsibility of the QAO to monitor the progress of the implementation of the corrective action and inform the Operations Director, the Technical Director and the Group Leaders of perceived and actual implementation problems. If external or internal audit resolution cannot be achieved in a timely manner, the Laboratory Director must be made aware of the problem and its consequences. When any audit finding would have a significant impact on the validity of a result, notice of the finding is given to any client whose work may have been affected.

10.3. Management Review

Shealy Environmental Services, Inc.

Page 88 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

A management review is conducted on an annual basis in order to evaluate the organization's quality and management systems, in order to ensure their continuing suitability and effectiveness, and to introduce any necessary changes or improvements. Further information concerning the annual management review is found in the Management Review policy (ME001HH). The management review is prepared by the QAO on an annual basis.

10.4. Client Complaints

Client complaints are generally received from the Project Managers. Client complaints are recorded, on the Client Complaint form (ME001W8). The form is completed and either a written or a verbal response is issued to the client by either a Project Manager, the QAO, the Operations Director, the Technical Director or the Laboratory Director. Completed complaint forms and responses are filed with QA. For a more detailed treatment of the client complaint process, see NCM, CAPA, Client Complaint and NIS SOP (ME001BO).

10.5. Client Surveys

In order to pro-actively take steps to monitor performance and service, EQI sends out Client Survey forms (ME001X0), to all clients once per year. Completed Client Surveys are submitted to the QAO. The surveys are reviewed and the results are presented to the management team. The completed surveys are filed with QA. After discussion and investigation, procedures or actions that can be improved upon based on client feed-back is evaluated for feasibility and initiated if no negative impact can be determined.

11. References

See Figure 11-1 for a list of sources.

Figure 11-1: References

Source	Source Reference
DoD DOE QSM 5.1.1	Department of Defense Department of Energy Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1.1, 2018.
TNI 2009	The NELAC Institute Environmental Laboratory Sector. TNI Standard. 2009.
ISO 17025	ASTM International. International ANS / ISO / IEC Standard 17025, Second Edition, 2005.
NELAC 2003	National Environmental Laboratory Accreditation Conference. 2003 NELAC Standard, 2003.
40CFR Part 136 - Appendix B	40CFR Part 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants, Appendix B: "Definition and Procedure for the Determination of the Method Detection Limit", <u>Code of Federal Regulations</u> , Revised July 1, 1995.
ASTM	1993 Annual Book of ASTM Standards, Section 11, Water and Environmental Technology, Volume 11.02, Water (II).
EPA QA / R-2	United States Environmental Protection Agency. EPA Requirements for Quality Management Plans, EPA QA / R-2, March 2001.
Standard Methods	Standard Methods for the Examination of Water and Wastewater, 21st Edition, 2011. Prepared and published jointly by: APHA, AWWA, and WEF.
SW-846	"The SW-846 Compendium." <i>EPA</i> . Environmental Protection Agency, 22 Feb. 2017. Web. 11 July 2017.
CLP (SOM)	US EPA CLP SOW SOM02.4 Organic Superfund Methods, Multi-Media, Multi-Concentration, October 2016.
CLP (ISM)	US EPA CLP SOW ISM02.4 Inorganic Superfund Methods, Multi- Media, Multi-Concentration, October 2016.

Shealy Environmental Services, Inc.

Page 90 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

APPENDIX A: Synopses of Key Technical Staff

Daniel J. Wright - Laboratory Director & President/CEO

Mr. Wright provides the overall direction of the company and is responsible for laboratory operations. He is accountable for building a winning environmental lab team, posturing the laboratory to be recognized as the best single site facility in the country as measured by providing on-time defensible data in diverse markets (CWA though CLP) and organizational excellence. He directs the efforts of the operations group, the information technology group, the project management group, and the sales and marketing group. He initiates all major capital expenditures. He executes facility design to accommodate growth in targeted business sectors, systematically and continuously adding state-of-the-art instrumentation, automation, LIMS technology, and top-talent; all of which will drive revenue, profitability, and allow for the rapid expansion of our facility. Mr. Wright is an essential contributor to our quality and safety programs, and is intimately familiar with ISO17025 and GLP. He provides technical support on method development, automation, instrument performance, and production efficiency. He has over 29 years of experience in environmental chemistry, QA/QC, and project management in environmental laboratory settings.

B.S. Biology, 1986, Manchester College, North Manchester, IN 16 years with EQI

Dr. Robert Zhu – Technical Director

Dr. Zhu provides technical direction to all laboratory areas. He is directly responsible for managing our contract with the USEPA Contract Laboratory Program. Dr. Zhu is a contributor to our quality assurance program, and is intimately familiar with ISO17025 and GLP. He also drives LIMS initiatives and IT efforts. He provides technical support on method development, automation, instrument performance, and production efficiency. He has over 22 years of experience in environmental chemistry, QA/QC, and project management in environmental laboratory settings. Dr. Zhu is the company's data integrity officer. As Alternate Radiation Safety Officer, he assists in the maintenance and compliance with EQI Radioactive Materials License program, policies, and procedures.

Ph.D. Physical Chemistry, 1994, University of South Carolina, Columbia, SC 18 years with EQI

Mike McFadden - National Sales Director

Mr. McFadden is the National Sales Director for Environmental Quantitation Incorporated. He is the primary contact for Federal Programs and the majority of the national contracts that EQI services. Mr. McFadden is responsible for the soliciting and procuring analytical work, contract negotiations and overall program management. Mr. McFadden has 26 years' experience in the Environmental industry.

B.S. Biology/Zoology 1986, North Carolina State University, Raleigh, NC B.S. Biochemistry 1987, North Carolina State University, Raleigh, NC 10 years with EQI

Bradley E. Belding – Operations Director

Mr. Belding is responsible for overall laboratory quality, and timely delivery of data to our clients. He is responsible for laboratory group leaders including volatiles, semi-volatiles, extractions, metals, inorganics, data

Shealy Environmental Services, Inc.

Page 91 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

review, and expanded deliverable data packaging. Mr. Belding drives process improvement initiates, provides solutions to operational challenges, and conducts training events. Mr. Belding has 25 years of experience from one of Test America's (TA) flagship laboratories, located in North Canton, OH. While at TA, Brad managed extractions, semi-volatiles, and expanded deliverables reporting. He has extensive knowledge of the demands of this industry, and utilizes this knowledge to optimize processes, improve data quality, and increase employee engagement. Mr. Belding has over 28 years of experience in the environmental industry.

B.S. Chemistry, 1987 University of Akron, OH 5 years with EQI

Neil Magee – Analytical Manager

Mr. Magee is responsible for technical support of the laboratory including method optimization and development, instrument maintenance, analyst training, Level II data review, cost-reduction and ordering of supplies. Mr. Magee has over 15 years of experience in the environmental industry. His other duties include serving as a floating senior analyst, testing and development of LIMS enhancements and driving continuous improvement efforts.

B.S. 1994 Environmental Management, Louisiana State University, Baton Rouge, Louisiana 12 years with EQI

Eleanor C. Cuaresma – Project Manager/Sample Receiving & Shipping Group Leader

Mrs. Cuaresma is the sample receiving/shipping group leader for the company. She has over 24 years of environmental laboratory experience. Her primary duties include supervising the receipt of all samples in accordance with our quality assurance management plan and SOPs. This includes: verifying preservation of each sample, performing chain of custody receipt, completing the sample receiving checklist, and entering all the sample identification and analyses requested into the LIMS. Mrs. Cuaresma is responsible for ensuring cradle-to-grave internal chain of custody procedures are followed for all samples.

B.S. 1978 Chemical Engineering, University of St. Tomas, Manila, Philippines 14 years with EQI

Wendy D. Plessinger – Quality Assurance Officer (QAO)

Ms. Plessinger has over 19 years of experience in the pharmaceutical and educational industries. She began her career as a quality control scientist at Pfizer Pharmaceuticals in Franklin, OH where she subsequently gained experience with GMP and FDA requirements as well as pharmaceutical process and method development. She furthered her experience as a quality control analyst at Ebewe Parenta Pharmaceuticals in West Columbia, SC where she was responsible for the product stability program. During her years at Parenta, she became an adjunct instructor at a local technical college where she taught science and problem solving skills for 4 years. Immediately prior to joining EQI she worked at the University of South Carolina where she was responsible for the daily operation of a Biogeochemistry research lab. Ms. Plessinger started at EQI as a QA Specialist and became the QAO in 2015 due to her strong experience and understanding of GLPs, quality systems, corrective and preventative actions (CAPAs), audits, inorganic chemistry, and training. She attends environmental conferences to further her knowledge of the industry.

M.S. 1995 Inorganic Chemistry, University of South Carolina, Columbia, SC

Shealy Environmental Services, Inc.

Page 92 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

4 years with EQI

Stephanie Atkins – Quality Assurance Specialist/ Environmental Health and Safety Officer/ Waste Manager/ Radiation Safety Officer

Mrs. Atkins functions as the Environmental Health and Safety Officer, Waste Manager, Radiation Safety Officer and Inorganics Non-Metals Assistant Group Leader for the analytical laboratory. She is responsible for providing initial safety and waste training to new personnel and all subsequent monthly refresher trainings. Her duties also include performing laboratory safety audits and maintaining internal health and safety plans to ensure compliance with all state and federal regulations. Mrs. Atkins is also responsible for maintaining compliance with all state and federal waste and hazardous materials regulations and supporting the QAO in all QA related activities. As Hazardous Waste Manager, she maintains EQI's compliance with all state and federal regulations. As Radiation Safety Officer, she maintains and enforces compliance with EQI Radioactive Materials License program, policies, and procedures.

B.S. 2007 Biology, University of South Carolina, Columbia, South Carolina 11 years with EQI

Cheryl R. Melton - Information Technology

Ms. Baker performs network administration and is actively involved in LIMS programming and development. She previously served as our quality assurance officer, inorganics group leader, and was a bench analyst. Additionally, Ms. Baker has vast experience with metals data evaluation and reporting. She has assembled CLP and CLP like deliverables utilizing the LIMS and EISC MARRS. Her knowledge of the inner working of the laboratory, coupled with her computer skills, allows her to be a very effective programmer.

M.E. 2002 Computer Engineering, University of South Carolina, Columbia, SC 24 years with EQI

Fran Stone –Senior Data Specialist

Ms. Stone has over 20 years' experience in metals analysis. This includes sample digestion, mercury analysis, ICP-AES analysis (200.7, 6010, CLP ISM), ICP-MS analysis (200.8, 6020, CLP ISM), and data regression and review. She is responsible for the generation and assembly of all CLP ISM and expanded deliverable data packages. She serves an integral role in the testing and development of software systems including MARRS and LIMS and provides feedback on enhancements. She serves as a trainer for all analysts on applicable features of MARRS and any updates/revisions. Ms. Stone also performs Level I and Level II review of data and serves as a backup ICP-AES and ICP-MS analyst as needed. Ms. Stone has had a leadership role at the laboratory since her early days and continues that today in her current position

B.S. 1987 Biology, St. Augustine's College, Raleigh, NC 27 years with EQI

Shealy Environmental Services, Inc.

Page 93 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Stephen Somerville – PFAS Analyst

Mr. Somerville has over 2 years' experience with semivolatiles and volatiles analysis. In the last year, he has developed our in-house PFAS methods which includes a modified 537 method including SPE preparation and isotope dilution analysis and a quick and dirty "dilute and shoot" method for screening. He has also been integral in setting up and validating our drinking water PFAS method (EPA 537).

B.S. 2010 Chemistry, Warren Wilson College, Swannanoa, NC 3 years with EQ

James Feldhaus - Metals Group Leader

Mr. Feldhaus has over 15 years' experience in metals analysis. He is responsible for metals analysis by 200.7/6010D and performs instrument maintenance. Mr. Feldhaus is the Inorganic Metals Group Leader and is responsible for scheduling and processing samples through the metals department, ensuring appropriate turnaround times are met, training new employees, ensuring QA objectives are met and reviewing SOPs for use and content. He performs and provides technical support on method development, method validation, automation and instrument performance. Mr. Feldhaus is the primary level 2 reviewer for all metals data when he is not the analyst.

B.S. 2000 Chemistry, North Carolina State University 1 year with EQI

Brittany Williams – Metals Analyst

Ms. Williams has over 8 years' experience in metals analysis. This includes sample digestion, mercury analysis, ICP-AES analysis (200.7, 6010, CLP ISM), ICP-MS analysis (200.8, 6020, CLP ISM), and data regression and review. She is a metals analyst and primarily analyzes samples by ICP-MS and ICP-AES. Ms. Williams performs data review, instrument maintenance and troubleshooting.

B.S. 2007 Biology, University of South Carolina, Columbia, SC 10 years with EQI

Cal Easter - Field Services Group Leader

Mr. Easter supervises all field activities performed by the field analytical services department. He served as Field Services Manager for 1 year at EQI's Charlotte Field facility and held the position of Field Services Technician prior to that. Field activities include: sample pickup, NPDES grab and composite sampling, low-level mercury collection (1669), soil sampling, groundwater sampling per RCRA protocols, and fish collection. He performs most of our routine groundwater monitoring sampling activities.

B.S. 2012 Geophysics, University of South Carolina, Columbia, South Carolina 6 years with EQI

Shealy Environmental Services, Inc.

Page 94 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Tracy Fowler – Inorganics Group Leader

Mrs. Fowler is responsible for the overall supervision of the inorganics department and has 28 years of experience in the environmental laboratory industry. She manages the daily departmental workload of the laboratory's largest department ensuring that sample holding times and analysis due dates are met. Mrs. Fowler has experience in the analysis of volatiles and semi-volatiles by GC/MS. She also has deep experience in the analysis of anions by ion chromatography (300/9056). Her key responsibilities include the training of analysts, method development and optimization, data review, and SOP review. She also services as an analyst as needed.

B.S. 1983 Physics, University of Waterloo, Waterloo Ontario, Canada 7 years with EQI

James Geiger -Semi-volatiles Group Leader

Mr. Geiger is responsible for the overall supervision of the GC/MS semi-volatiles department with over 6 years of experience in the industry. His duties include method development, training of analysts, analyzing samples, data review, SOP review and managing the daily departmental workload to meet deadlines. Mr. Geiger also assists in the daily organics supervision.

B.S. 2006 Biology, University of South Carolina, Columbia, SC 12 years with EQI

David Lucas – Extractions Group Leader

Mr. Lucas is responsible for the daily operation of the organic extractions department. He has been performing organic extractions and GPC on water, soils, sludge, and sediment samples in accordance with EPA methods for over two years.

B.S. 2007 Biology, University of South Carolina, Columbia, South Carolina 8 years with EQI

Erin Boyd - Volatiles Group Leader

Mrs. Boyd has over 16 years' experience in volatiles analysis. This includes sample preparation and GC/MS analysis for various EPA methods (i.e. 8260, 624, RSK-175). She is a volatiles analyst and primarily analyzes samples by GC/MS. Mrs. Boyd performs data review, instrument maintenance and troubleshooting.

B.S. 2000 Chemistry, Dickinson College, Carlisle, PA 2 year with EQI

Grant R. Wilton - Project Manager

Mr. Wilton has over 25 years of experience in the environmental industry and over 15 years' experience as a project manager. Mr. Wilton's Project Manager duties include management of client project activities from sample receipt through data review and report generation.

B.S. 1981 Water Science, Northern Michigan University, Marquette, Michigan 11 years with EQI

Shealy Environmental Services, Inc.

Page 95 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Lucas J. Odom – Project Manager

Mr. Odom is the Project Manager for many of our South Carolina and North Carolina NPDES clients as well as our SCDHEC drinking water program. Mr. Odom has past experience as our field service assistant group leader where he gained valuable knowledge of many sampling techniques including: composite sampling, well sampling, soil sampling, and LL-Hg sampling. As a Project Manager, his duties include management of client project activities from sample generation through data review and report generation.

M.S. 2008 Environmental Health Sciences, University of South Carolina 10 years with EQI

Nisreen M. Saikaly - Project Manager

Mrs. Saikaly functions as the project manager for our government, and government like deliverable client base. As the primary point of contact for these clients, she provides cradle-to-grave project management for continuing projects as well new projects. Her duties include planning kick-off meetings, providing price quotations, coordinating sample kit shipping, reviewing Chain of Custody (COC) information against information entered into LIMS, communicating any COC discrepancies and sample analysis anomalies to client, providing updates on project status, monitoring client-specified TAT, assuring deliverable requirements are met, and final review and release of reports. Mrs. Saikaly's experience includes being an analyst in the laboratory as well as QA. Her QA experience allows her to assist with regulatory-specific methods and special project requirements and QAP review.

B.S. 2002 Chemistry, University of Toronto, Toronto Canada 12 years with EQI

Kelly M. Nance -Project Manager

Ms. Nance functions as the project manager for our NPDES projects in NC and SC as well as project specific accounts. She will also be managing all new accounts from TN, GA, AL and MS. Ms. Maberry has over 7 years' experience as a PM as well as being an analyst in the Sample Receiving Dept. for 3 years. Her experience with the Laboratory Information Management System (LIMS) and logging in analytical assignments from Chain of Custody forms allows her to accurately assess correct method assignment and project specific requirements. She is highly knowledgeable regarding method specific parameters that require special attention from lab personnel (short hold times, preservation requirements, etc.).

B.S. 1995 Biology, University of South Carolina, Columbia, South Carolina 8 years with EQ

I

Shealy Environmental Services, Inc.

Page 96 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Cathy Dover – Project Manger

Ms. Dover has over 32 years of experience in the environmental laboratory with over 16 years as a project manager. Ms. Dover manages commercial clients as well as USEPA Contract Laboratory Program. As the primary point of contact for these clients, she provides cradle-to-grave project management for continuing projects as well new projects. Her duties include planning kick-off meetings, providing price quotations, coordinating sample kit shipping, reviewing Chain of Custody (COC) information against information entered into LIMS, communicating any COC discrepancies and sample analysis anomalies to client, providing updates on project status, monitoring client-specified TAT, assuring deliverable requirements are met, and final review and release of reports. Ms. Dover has a wide range of experience that includes being an analyst to working sample receiving/shipping as well as QA. All of this experience allows her to assist with regulatory-specific methods and special project requirements.

1980 - 1983 Chemical Engineering / Chemistry / Science Education, North Carolina State University, Raleigh, NC

2 years with EQI

Shealy Environmental Services, Inc.

Page 97 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

REVISION HISTORY

Original Document #: Q-QA-001 Rev 14

Rev 14 to Rev 01

-Changes were documented in EQLIMS via tracked changes in Word

Rev 01 to Rev 02

- -Figure 1.7-1 Updated Management Org Chart
- -Section 1.8 Updated subsections per re-organization of the company this year
- -Sections 1.8.4, 1.8.9, 1.8.10, 1.8.17 were added
- -Figure 1.10-1 Updated Ethics Policy Agreement
- -Section 3.2 Deleted paragraph on renewal DOCs after failure
- -Section 4.1 Clarified the use of the Vendor Registration form and corrected the way in which Shealy keeps track of its approved vendors and laboratory subcontractors
- -Section 4.2.4 Clarified what items purchased require a COA
- -Changed SOM02.2 and ISM02.2 to SOM02.3 and ISM02.3 throughout the document
- -Section 5.2.2.3 Updated SOP header information and added some information about EQLIMS Media
- -Section 7.3.1.1 Updated to reflect current practice of maintaining the DI water system
- -Figure 7.3-1 Added new Ion Chromatograph and new water bath
- -Section 9.1.3 added that absorbent padding is used when packing bottles that contain preservatives
- -Figure 9.2-3 Updated CWA/NPDES Chain of Custody form
- -Figure 9.3-1 Updated Sample Receipt Checklist
- -Figure 10.2-1 Updated Currently Approved SOPs list
- -Resumes of Key Technical Staff Updated several; added Roger Toth

Rev 02 to Rev 03

- -Section 1.1 Added Kentucky Certification, removed New Jersey
- -Figure 1.7-1 Updated Management Org Chart
- -Section 1.8.3 Updated QA Specialist responsibilities
- -Section 1.8.4 Updated QA Associate responsibilities
- -Figure 1.10-1 Updated Ethics Policy Agreement version
- -Section 3.1.3.2 Added statement that Technical Director cannot be a Technical Director of more than one accredited laboratory without authorization.
- -Section 5.2.2.3 Updated section to include changes made to document system due to EQLIMS
- -Section 5.3.1.3 Added: "An electronic pdf of the QAMP is also available on the public drive and/or in EQLIMS for easy access by all employees."
- -Section 5.3.2 Updated LIMS hardware information to current LIMS SOP.
- -Section 6.9.1 Computer Security Section updated to current LIMs SOP.
- -Figure 7.0-1: Shealy Facility Layout Updated
- -Section 7.1.1 Added: "...for ventilation while opening sample coolers as well as..."
- -Section 7.1.5- Added additional metals hood and vented sample storage cabinets to Metals laboratory information.
- -Section 7.1.6- Updated Inorganic non-metals instrumentation
- -Figure 7.3-1 Major Operation Equipment List Updated: New equipment added, removed equipment no longer in service, Field Services-Greenville added.
- -Figure 7.3.1.1 Added note at bottom of figure
- -Figure 9.1-5: ISM02.3 Inorganic Sample Containers, Preservatives, and Holding Times corrected Cyanide (SPLP) preservation.
- -Figures 9.2-2 & 9.2-3 Updated to current chains
- -Figure 9.3-1: Updated Sample Receipt Checklist version
- -Figure 10.2-1: Currently Approved SOPs Updated SOP IDs from legacy document numbers to EQLIMS document numbers where applicable.
- -Figure 10.6-1: Moved top loading balances to same row as analytical same acceptance criteria applies to both; Updated fume hood criteria and frequency
- -Section 10.8 Removed allowance of 3 ring binders. Updated logbook review policy.
- -Throughout Document-Updated document IDs from legacy document numbers to EQLIMS document numbers where applicable.
- -APPENDIX A: Resumes of Key Technical Staff- Updated for changes in key personnel
- -Sections with minor edits: 5.2.1.3, 7.1.1, 7.1.7

Shealy Environmental Services, Inc.

Page 98 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

Rev 03 to Rev 04

-Updated resumes of key staff

Rev 04 to Rev 05 (all references are for Rev 05 sections)

- -Reorganized QAMP to align more with EPA QA/R-2 and to streamline the flow of the document
- -Changed name of company throughout
- -Changed PQL to LOQ throughout
- -Deleted most figures/tables and added them as part of the addendum where necessary
- -Section 1.1.1 Added KS certification and that a list of current certifications is found in the addendum; corrected state program names where needed; updated accrediting bodies with more details
- -Section 2.2 Updated list of those with authority to sign off for business matters and for areas of expertise
- -Section 2.3 Added that org chart is in addendum
- -Sections 2.3.1 through 2.3.22 Updated and/or added job responsibilities
- -Section 2.4.2 Updated definition of quality assurance and quality control, added examples of QA, updated purpose of the QAMP
- -Section 2.5.1.2 Updated list of quality records
- -Sections 3.1.2.1 through 3.1.2.11 Updated experience requirements
- -Section 3.2 Added HS/HW training
- -Section 3.2.1.1 Deleted copy of ethics policy, added reference to ethics policy; added "data integrity" to heading
- -Section 3.2.4 Updated those involved in general lab training
- -Section 3.3 Clarified what ongoing training consists of
- -Section 3.4 Clarified QAO training
- -Section 4 Deleted detailed info which is found in the SOP, added what the procurement SOP includes, added that purchased services includes repair and maintenance of equipment and instruments
- -Section 5.1.2 Added limit to the review frequency for the SOPs and the QAMP
- -Sections 5.2 & 5.3 Added forms and spreadsheets
- -Section 5.5.1 Updated info on data backup
- -Section 6 Added QA functions document control and training to list of ways computers are used, added reference to LIMS User Guide SOP
- -Section 6.1 Added EQLIMS description and that it is currently used to support QA
- -Section 6.1.6 Added that EQLIMS is used for editing report narrative, storage and retrieval
- -Sections 6.1.5, 6.1.7 through 6.1.9, 6.1.10 Added sections on new EQLIMS applications
- -Sections 6.2.1 through 6.2.3 Added sections on data management software Target, AIM and MARRS
- -Section 6.3 Added further description of industry standard software, added more details on verification and updated how software is verified, added audit trail function is enabled
- -Section 6.4 Updated description of LIMS hardware
- -Section 6.5 Added that industry standard software training is initially given by the manufacturer or by an experienced user
- -Moved equipment list from body of QAMP to the addendum
- -Moved method/SOP list to the addendum
- -Section 7.4 Added reference to list of methods is found in addendum, added that program area in LIMS dictates QC
- -Section 7.5.3 Added reference to procurement SOP
- -Section 7.5.4 Updated power failure system safeguards
- -Sections 8.2.1 through 8.2.8 Updated laboratory area information, added LC/MS/MS lab
- -Section 8.3 Section 8.3.1 Clarified that equipment list is in addendum
- -Section 8.3.4 Updated info on hydrogen gas and added zero air gas generator
- -Section 8.3.5 Deleted sentence stating that method SOPs contain glassware cleaning instructions
- -Deleted container, preservation, hold time tables from body of QAMP
- -Sections 8.4.1.1, 8.4.1.1.1 Added that container, preservation, hold time table is in addendum
- -Section 8.4.1.2 –Removed details found in the shipping SOP, added reference to the SOP
- -Section 8.4.2 -Added definition of chain of custody, updated definition of possession
- -Deleted field data sheet figure
- -Section 8.4.3 Added reference to sample receiving SOP
- -Updated SRC figure
- -Section 8.4.4.1-Deleted details found in the storage blank SOP and added reference to the SOP
- -Section 8.4.4.2.1 Added info about CLP storage blanks
- -Section 9.1.6.2 Added section on detection limit
- -Sections 9.1.6.3 & 9.1.6.4 Simplified info about LODs & LOQs

Shealy Environmental Services, Inc.

Page 99 of 100

Document Number: ME0012K-06

Effective Date: 7/13/2018

- -Section 9.2 Added that QC sample data is used to satisfy the DQOs
- -Section 9.2.1.3 Added how many trip blanks are required
- -Deleted laboratory QC sample table
- -Section 9.2.2.2 Added glass beads
- -Sections 9.2.2.3 & 9.2.2.4 -Added ICV and ICB
- -Section 9.2.2.5 Added CCB
- -Section 9.2.2.6 Added CCV
- -Section 9.2.2.7 Added that one LCS is analyzed with each batch
- -Section 9.2.2.12 Added two types of IS
- -Section 9.2.2.15 Added post spike sample
- -Section 9.3.2 Updated equipment requiring periodic verification, added that NIST standards are used, added that some verifications are done by outside vendors
- -Section 9.3.3.1 Added used of ICV
- -Section 9.4 Clarified the examples
- -Section 9.5 Deleted details found in the standards SOP and added reference to the SOP, added reference to procurement SOP
- -Section 9.6 Deleted details found in the logbook SOP and added reference to the SOP
- -Deleted duplicate significant figures and rounding rules sections
- -Section 9.7 Added "Level 1" language to section to clarify
- -Sections 9.7.1 9.7.3 Updated review processes
- -Sections 9.8.2 through 9.8.7 Updated evaluation criteria and corrective action where necessary
- -Sections 9.8.9.1 & 9.8.9.2 Updated control limit evaluation tables and footnotes
- -Section 10 Added introductory statements about the section subject
- -Section 10.1 Added that deviations from SOPs are documented in an NCM, Added reference to the NCM SOP, deleted reference to the legacy paper NCM procedures
- -Section 10.1.4 through 10.1.6 Clarified system NCM, CAPA and NIS processes
- -Section 10.2.1 Updated table and added reference to the internal audit SOP
- -Section 10.3 Added reference to the management review SOP, clarified the use of the review
- -Section 10.4 Updated client complaint section to current practice
- -Section 11 Updated table of references
- -App A Updated/corrected wherever necessary
- -Addendum Updated list of items included in addendum

Rev 05 to Rev 06

- -Section 2.3 Moved management structure figure (Figure 2.3-1) to the addendum and updated section accordingly.
- -Section 3.1.2.4 Changed 2 year degree requirement from required to preferred
- -Section 3.2.1.1 Added 3rd paragraph to this section describing notifying Shealy's DoD accrediting body of instances of inappropriate or prohibited laboratory practices
- -Section 3.3 Added that reviewers and approvers of SOPs and policies are considered trained on those documents
- -Section 8.5 Added section on sustainability
- -Section 9.1.6.3 Updated MDL reference
- -Section 9.1.6.3.1 Updated the frequency of required MDL verifications from annually to quarterly
- -Section 9.7.4 Added section describing level IV package review
- -Section 9.9.5 Added reference to the CLP data package policy
- -Section 10.1.5 Updated CAPA section to reflect use of EQLIMS CAPA app
- -Section 11 Figure 11-1 Updated DoD DOE OSM reference
- -Appendix A Updated years of service, updated position for Stephanie Atkins and Erin Boyd; Added Stephen Somerville and Jim Feldhaus; Deleted Dede Dalton, Candice Hopkins and Angela Lockwood

Shealy Environmental Services, Inc.

Page 100 of 100

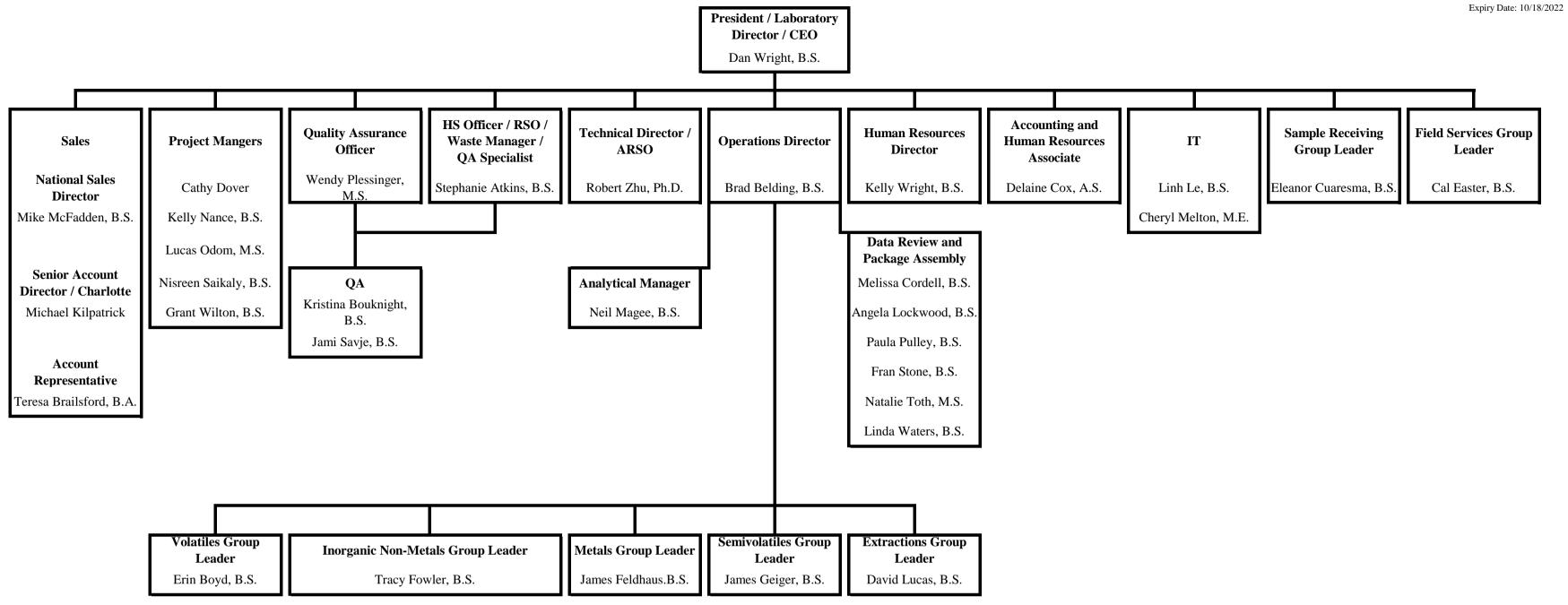
Document Number: ME0012K-06

Effective Date: 7/13/2018

Addendum to the Quality Assurance Management Plan

This addendum contains the following documents. These documents are not contained in the pagination of the QAMP and may change without revision to the QAMP.

- Management Organizational Chart (ME0018S)
- Organizational Chart (ME0013A)
- Major Operational Equipment List (ME001PM)
- Certification List (ME001PL)
- EQI Analytical Methods (ME002BS)
 - o Sample containers, preservatives, and holding times
 - o Analytical SOP list
 - o Parent methods list
- SOPs and policies list EQLIMS



Stephen Somerville,

B.S.

Jon Kilpatrick

Jeongmi Moon, Ph.D

Mallory Small, B.S.

Brian Smith, M.S.

Kristen Towey, B.S.

Maria Gonzalez, B.S.

Kristen Jensen, B.S.

Alicia Robinson, B.S.

Svetlana Uzunova,

B.S

Major Operational Equipment List										
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes		
			Extractions		_	,				
Microwave Reaction System	MCW #2	CEM	MARS6 230/60	MJ6109	5/2015	NA	New			
GPC	GPC #1	J2 Scientific	AccuPrep	03H-1083-3.0	12/2003	ChemPlus V. 22.1				
GPC	GPC #2	J2 Scientific	AccuPrep MPS	05C-1148-4.0	11/01/05	ChemPlus V. 20.6				
Ultrasonic Disruptor	Ultrasonic Disruptor #1	Misonix (Qsonica)	Sonicator 3000	R02998	2006	NA				
Ultrasonic Disruptor	Ultrasonic Disruptor #2	Misonix (Qsonica)	Sonicator 3000	R2374	Unknown	NA				
Ultrasonic Processor	Ultrasonic Processor #2	Misonix (Qsonica)	Sonicator Q700	78274E	1/16/2014	NA				
Ultrasonic Processor	Ultrasonic Processor #3	Qsonica	Sonicator Q700	86849J	9/22/2015	NA	New			
Turbo Vap II Concentrator	Turbo Vap II Concentrator #3	Caliper Life Sciences	103187/0	TV0525N12376	07/2005	NA				
Turbo Vap II Concentrator	Turbo Vap II Concentrator #2	Zymark	46368/0	TV0020N9579	05/11/2000	NA				
Turbo Vap II Concentrator	Turbo Vap II Concentrator #1	Zymark	46368/0	TV9908N8685	01/04/2000	NA				
Turbo Vap II Concentrator	Turbo Vap II Concentrator #4	Zymark	ZW 8001	O3987	1993	NA				
Turbo Vap II Concentrator	Turbo Vap II Concentrator #5	Biotage	Turbo Vap II	TV1418N20407	08/2014	NA				
Turbo Vap II Concentrator	Turbo Vap II Concentrator #6	Biotage	Turbo Vap II	TV1434N20575	10/23/14	NA				
Turbo Vap II Concentrator	Turbo Vap II Concentrator #7	Biotage	Turbo Vap II	TV1633N21597	11/22/2016	NA				
Turbo Vap II Concentrator	Turbo Vap II Concentrator #8	Biotage	Turbo Vap II	172500072	09/12/2017	Turbovap Software V.1.02.09	New			
Turbo Vap II Concentrator	Turbo Vap II Concentrator #9	Biotage	Turbo Vap II	173000101	09/13/2017	Turbovap Software V.1.02.09	New			
Turbo Vap II Concentrator	Turbo Vap II Concentrator #10	Biotage	Turbo Vap II	181200445	06/06/2018	Turbovap Software V.1.02.09	New			
Turbo Vap II Concentrator	Turbo Vap II Concentrator #11	Biotage	Turbo Vap II	181400458	06/06/2018	Turbovap Software V.1.02.09	New			
TCLP Rotary Sample Agitator	TCLP Rotary Sample Agitator #1	Associated Design	3740-12-BRE 12 Station	1528	1998	NA				
TCLP Rotary Sample Agitator	TCLP Rotary Sample Agitator #2	Associated Design	3740-12-BRE 12 Station	1061	2005	NA				
Water Bath	Water Bath #2	Boekel	1494	24149012	01/2003	NA				
Water Bath	Water Bath #3	Boekel	1494	52202304	06/22/05	NA				
Wrist Shaker	Wrist Shaker #1	Burrell	75	NA	1990	NA				
Muffle Furnace	Furnace #1	Lindberg/Blue M	BF51828C-1	P04N-623993-PN	06/2003	NA				
Muffle Furnace	Furnace #2	Lindberg/Blue M	BF51828C-1	O10N-620675-ON	6/1/2003	NA				
Muffle Furnace	Furnace #3	Lindberg/Blue M	BF51828C-1	R23M-579155-SM	07/2002	NA				
Muffle Furnace	Furance #5	ThermoScientific Lindberg/Blue M	BF51828C-1	J11A-164949-JA	9/17/2015	NA	NEW			
Oven	Oven #EXT13-820	Quincy Lab	410GC Series Lab Oven	G4-006881	08/20/2013	NA				
Drying Oven	Drying Oven #5	Baxter	DK43	189001	1998	NA				
Drying Oven	Drying Oven #7	Quincy Lab	10GCE	G1E-00440	43257	NA	New			
Balance	Balance #25B	Mettler & Toledo	PB1502-S	1120493684	8/8/2012	NA				
Speed Vap	Speed Vap #2	Horizon Tech	Speed-vap IV	15-0039	9/17/2015	NA	NEW			
Balance	Balance #13-1016	Mettler Toledo	ML802E/03	B326486754	10/16/2013	NA				
Automated Turner	Turner # 1	DFIT	Custom Build	Custom Build	05/01/2017	NA	NEW			
			Field Services - Colum	nbia			<u>'</u>			
DO Meter	DO Meter #3	YSI	Pro 20	148104784	Unknown	NA	T			
Composite Sampler	Composite Sampler #2	ISCO	3710	205E01372	Unknown	NA				
Composite Sampler	Composite Sampler #3	ISCO	3710	212B00320	Unknown	NA				
Composite Sampler	Composite Sampler #4	ISCO	3710	206D00712	Unknown	NA				
Composite Sampler	Composite Sampler #6	ISCO	3710	205K0152	Unknown	NA				
Composite Sampler	Composite Sampler #7	ISCO	3710	200A01650	Unknown	NA				
Composite Sampler	Composite Sampler #8	ISCO	3710	213F01221	Unknown	NA				
pH Meter	pH Meter #37	Thermo Scientific	Orion Star A321	G03795	04/02/2013	NA				
pH Meter	pH Meter # 104	YSI	Pro 10	18B102977	03/08/2018	NA	New			
r	F	1 - ~ -	1 10		03,03,2010	- ·- *				

Shealy Environmental Services, Inc. Document Number: ME001PM-21 Page 2 of 12 Effective Date: 7/16/2018

	Major Operational Equipment List										
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes			
pH Meter	pH Meter #101	Thermo Scientific	Orion Star A321	G07576	6/10/2016	NA	New				
DO Meter	DO Meter #5-C	YSI	55	03K0073	7/15/2011	NA					
pH Meter	pH Meter #0615	Thermo Scientific	Orion Star A221	K06773	06/07/2015	NA	New				
Peristaltic Pump	Peristaltic Pump #1	ISCO	150	203G01007	2004	NA					
Flow Meter	Flow Meter #1	ISCO	3210	11700-024	1994	NA					
Handheld Stream Flow Meter	Handheld Stream Flow Meter	Scientific Instruments Inc.	CM9000	1152	1992	NA					
TRC Meter	TRC Meter #9	Hach	Pocket Colorimeter II	700148712	07/2000	NA					
Redi-Flo Pump	Redi-Flo Pump #1	Grundfos	BMI MPI	P194001331	1995	NA					

			Major Operational Equip	oment List				
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes
Redi-Flo Pump	Redi-Flo Pump #2	Grundfos	BMI MPI	P194001334	1995	NA		
RC Meter	TRC Meter #TRCM-1210	Hach	Pocket Colorimeter II	12070E203659	9/10/2012	NA		
RC Meter	TRC Meter #TRCM-0615	Hach	Pocket Colorimeter II	15050E272953	7/1/2015	NA		
Aultimeter	Multimeter # 2	YSI	Pro1030	16K102983	11/9/2016	NA		
Turbidimeter	Turbidimeter #TM-1114	Hach	2100Q	13080C027705	11/14/2013	NA		
oH Meter	pH Meter #103	Thermo Scientific	Orion Star A321	G09500	12/10/2017	NA	New	
			Field Services-Char					
Composite Sampler	Composite Sampler #1-C	Isco	3710	12471-066	Unknown	NA		
Composite Sampler	Composite Sampler #2-C	Isco	3700	09078-115	Unknown	NA		
Composite Sampler	Composite Sampler #3-C	Isco	3710	213K01144	Unknown	NA		
Composite Sampler	Composite Sampler #4-C	Isco	3710	200B02589	Unknown	NA		
Composite Sampler	Composite Sampler #5-C	Isco	3710	08008-019	Unknown	NA		
Composite Sampler	Composite Sampler #6-C	Isco	2910	197M01047	Unknown	NA		
Composite Sampler	Composite Sampler #7-C	Isco	2910	07983-001	Unknown	NA		
Composite Sampler	Composite Sampler #8-C	Isco	2910	08105-046	Unknown	NA		
Composite Sampler	Composite Sampler #9-C	Isco	2910	197B01220	Unknown	NA		
Conductivity Meter	Conductivity Meter #1-C	YSI	32/11SPD	04IJ071BC	05/2007	NA		
OO Meter	DO Meter #2	YSI	Pro 20	13A101442	1/2013	NA		
OO Meter	DO Meter #1	YSI	Pro 20	06F2811AG	2006	NA		
H Meter	pH Meter #13-820	Thermo Scientific	Orion Star A221	H01668	Unknown	NA		
H Meter	pH Meter #102	Thermo Scientific	Orion Star A221	K00643	Unknown	NA		
H Meter	pH Meter #100	Thermo Scientific	Orion Star A221	G07625	3/23/2016	NA	New	
RC Meter	TRC Meter #8	Hach	Pocket Colorimeter II	40700019648	2002	NA		
RC Meter	TRC Meter #TRCM-1210A	Hach	Pocket Colorimeter II	12070E203555	9/10/2012	NA		
RC Meter	TRC Meter #TRCM-1210B	Hach	Pocket Colorimeter II	12070E203545	9/10/2012	NA		
ow Level TRC Meter	LL TRC Meter #1	Hach	DR2700	1353696	03/29/2011	NA		
Low Level TRC Meter	LL TRC Meter #2	Hach	DR2800	1177995	Unknown	NA	Used	
			Field Services-Green	nville	<u>'</u>			'
OO Meter	DO Meter # 6	YSI	Pro ODO	18B103680	3/8/2018	NA	New	ProODO Probe 18B103921
H Meter	pH Meter #0215	Thermo Scientific	Orion Star A221	K07028	2/12/15	NA	New	
Composite Sampler	Composite Sampler #1	ISCO	3710	212K00187	Unknown	NA		
Composite Sampler	Composite Sampler #5	ISCO	3710	213A00834	Unknown	NA		
Composite Sampler	Composite Sampler #9	ISCO	3710	214H00829	Unknown	NA		
Composite Sampler	Composite Sampler #G-1	ISCO	3710	216A00118	02/2016	NA	New	
			Inorganic Metal	s	<u> </u>			
nductively Coupled Plasma- Frace	ICP #4	Thermo Scientific	iCAP6500	20074003	02/01/08	iTEVA 2.8.0.97		
CP Autosampler	ICP Autosampler #1	Teledyne Cetac Technologies	ASX-520	0811118A520	Unknown	NA		
nductively Coupled Plasma- Frace	ICP #5	Thermo Scientific	iCAP7600	IC76DU134102	01/2014	iTEVA 2.8.0.96		
CP Autosampler	ICP Autosampler #2	Teledyne Cetac Technologies	ASX-520	083142A520	Unknown	NA		
CP-MS	ICP-MS # 4	Thermo Scientific	iCAP RQ	iCAPRQ00715	1/11/2018	Qtegra 2.8.3170.309		
CP Autosamples	ICP Autosampler # 5	Teledyne Cetac Technologies	ASX-560	111742A560	1/19/2018	NA		
CP-MS	ICP-MS #3	Thermo Scientific	iCAP O	SN02702R	02/2014	Qtegra 2.8.2944.249		
CP Autosampler	ICP Autosampler #3	Teledyne Cetac Technologies	ASX-520	0715122A520	Unknown	NA		
CP-MS	ICP-MS #2	Thermo Scientific	XSERIES 2	0686C	06/2011	Thermo PlasmaLab 2.6.2.337		
CP Autosampler	ICP Autosampler #4	Teledyne Cetac Technologies	ASX-520	1013129A520	Unknown	NA		
*	•					Envoy 2.0 SPO		
Mercury Analyzer CVAA	Hg #4	Leeman Labs	Hydra AA	4004	02/2014	Version 6.1		

Shealy Environmental Services, Inc.
Document Number: ME001PM-21

Effective Date: 7/16/2018

	Major Operational Equipment List										
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes			
Hot Block Graphite Heater	Hot Block #4	Environmental Express	SC154	3098CEC15414	11/1/04	NA					
Balance - Top Loading	Balance #9B	Mettler Toledo	MS3035	B125154017	08/2011	NA					
Hot Block Graphite Heater	Hot Block #6	CPI	MOD/BLOCK	NA	02/2016	NA					
Hot Block Graphite Heater	Hot Block #7	CPI	MOD/BLOCK	NA	06/2016	NA					
Hot Block Graphite Heater	Hot Block #8	CPI	MOD/BLOCK	QB160028	11/30/2016	NA					
Hot Block Graphite Heater	Hot Block #9	Environmental Express	SC154	2018CEC4882	06/28/2018	NA	New				

			Major Operational Equ	ipment List				
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes
Chiller	Chiller #1	ThermoFisher Scientific	ThermoFlex 2500 / 21123010000008	0110795501131104	Unknown	NA		
Chiller	Chiller #2	ThermoFisher Scientific	ThermoFlex 2500 / 121123010000008	0110399701130116	Unknown	NA		
Chiller	Chiller #3	ThermoFisher Scientific	ThermoFlex 2500 / 121123010000008	0127181101140707	Unknown	NA		
Chiller	Chiller #4	ThermoFisher Scientific	ThermoFlex 2500 / 121123010000008	0127369001141120	Unknown	NA		
Quick Trace Mercury Analyzer CVAF)	Hg #5	Teledyne Cetac Technologies	M-8000	US17076012	5/2/2017	Quick Trace Version 3.1.0	New	Leeman Labs
Quick Trace Autosampler	Hg Autosampler #5	Teledyne Technoliges	ASX-560	03174A560	5/2/2017	NA		
			Inorganic Non-M	letals				
Aquakem 200 Analyzer	Aquakem Analyzer #1	Thermo Scientific	984206	F-4720950	02/2007	Aquakem 200 6.6.1		
Aquakem 200 Analyzer	Aquakem Analyzer #2	Thermo Scientific	984206 (type: 973)	22831	05/2013	Aquakem 200 7.2.AQ2		
Ion Chromatograph	IC #3	Dionex	ICS-2000	4040839	8/2004	Chromeleon Version 7.2 SR3 (7553) (154962)		
IC Autosampler	IC Autosampler #1	Dionex	AS40 Automated Autosampler	98060814	8/2004	NA		
C Pump	IC Pump #1	Thermo Scientific	Dionex AXP	Z0053278	12/2014	NA	New	
C Variable Wavelength	IC VWD #1	Thermo Scientific	Dionex VWD	14101375	12/2014	NA	New	
Ion Chromatograph	IC #4	Dionex	ICS-2100	9050165	8/6/2012	Chromeleon Version 7.2 SR3 (7553) (154962)		
IC Autosampler	IC Autosampler #2	Dionex	AS40 Automated Autosampler	4070951	8/6/2012	NA		
IC Autosampler	IC Autosampler #3	Dionex	AS40 Automated Autosampler	98070231	Unknown	NA		
Ion Chromatograph	IC #5	Thermo Scientific	Dionex ICS-2100	13010346	10/15/2015	Chromeleon Version 7.2 SR3 (7553) (154962)	New	
IC Autosampler	IC Autosampler #4	Thermo Scientific	Dionex AS-DV	1508100374	10/15/2015	NA	New	
Auto-Titrator System			PCM-1002/4	NA	12/13/2017	PC-Titrate For Windows V3 Version 3.0.0.889		
Autosampler			PC-1000-688	261C4N066	2002	NA		
PC-Titrate Titra-Rinse/A			PCM-1000-408	MS-0G0-118	2002	NA		
PC-Titrate Titra-Rinse/A			PCM-1000-408	MS-0F1-137	2002	NA		
PC-Tis Interface Module	Auto-Titrator #AT	Man-Tech	PC-1000-102	MS-0E2-308	2002	NA		
GT-ID-II			PCM-1000-495	CIL-00296	2002	NA		
Curbidity Assay Plus			PC-20013A	209090	2002	NA		
Buret Module			PC-1000-1040	MT-1G7-200	12/13/2017	NA	New	
Mini Mix Stirrer Controller			PC-1000-388	MT-1C7-375	12/13/2017	NA	New	
Peristaltic Pump			PC-1000-475	MT-1H7-420	12/13/2017	NA	New	
Titrasip Module			PC-1300-475	MT-1E7-1014	12/13/2017	NA	New	
Conductivity Meter	Conductivity Meter #AT3	Man-Tech	4510	66959	12/13/2017	NA	New	
Conductivity Meter	Conductivity Meter #AT2	Extech Instruments	EC100	301884	9/2/2016	NA	New	
Auto Analyzer System	AA #2	Lachat	Quick-Chem 8000	A83000-1990	2002	Omnion 3.0.220.06		
Spectrophotometer	Spectrophotometer #4	Hach	DR 3900	1606201	6/30/15	NA	New	
ΓΟC Analyzer	TOC #1	OI Analytical	1030	J019730196	06/2010	Aurora SW V1.4.2		
TOC Autosampler	TOC Autosampler #1	OI Analytical	1088 AS	E018788107	06/2010	NA		

Major Operational Equipment List										
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes		
Ignition Unit	Ignition Unit #1U1012	Parr	2901EB	NA	10/4/2012	NA				
Turbidimeter	Turbidimeter #3	HF Scientific	Micro 100	201610276	12/5/2016	NA				
Cyanide Hotblock	Cyanide Hotblock #1	Andrews	110-10R	AIS0142	2000	NA				
Cyanide Hotblock	Cyanide Hotblock #2	Andrews	110-10R	A8M0309	02/1999	NA				
Cyanide Hotblock	Cyanide Hotblock #3	Andrews	110-10-12	A5P0842	12/14/2015	NA				
Cyanide Hotblock	Cyanide Hotblock #4	Andrews	110-10-P	86N0892	1/25/2017	NA	New			
Bomb Calorimeter	Bomb Calorimeter #1	Parr	1341EB	7303	1997	NA				
TKN Hot Block	TKN Hot Block #3	Lachat	BD40	HTLC1015360440/TSLA101506	10/27/2015	NA				
COD Digestion Block	COD Digestion Block #3	Columbia Analytical Instruments	Smart Block 226	NA	2/10/2014	NA				
COD Digestion Block	COD Digestion Block #2	Lovibond	2418938	41160906	2009	NA				
Phenol Distillation Unit	Phenol Distillation Unit #3	Andrews	110-10-PA	12N0222	01/2003	NA				
Phenol Distillation Unit	Phenol Distillation Unit #2	Andrews	110-10-PA	1LX0305	06/2001	NA				
Phenol Distillation Unit	Phenol Distillation Unit #4	Andrews	110-10-PA	16T0022	Unknown	NA				
Phenol Distillation Unit	Phenol Distillation Unit #5	Andrews	110-10-PA	1170352	03/2015	NA				
Balance - Analytical	Balance #11A	Mettler Toledo	MS204S	B427764304	8/6/14	NA	New			
Balance - Analytical	Balance #12	Mettler Toledo	MS-204TS	B539502279	10/1/2015	NA	New			
Luminescence Dissolved Oxygen Meter	DO Meter #4	YSI	ProODO	15K102490	11/16/2015	NA	New	ProODO Probe 15K100957		
Luminescence Dissolved Oxygen Meter	DO Meter #5	YSI	ProODO	16B100776	2/18/2016	NA	New	ProODO Probe 16B100987		
Luminescence Dissolved Oxygen Meter	DO Meter #7	YSI	ProODO	18E102940	5/30/2018	NA	New	ProODO Probe 15K100957		
pH Meter	pH Meter #12	VWR	SB70P	D05976	11/22/10	NA	New			
pH Meter	pH Meter #14	Thermo Scientific	STARA1110	J14050	8/9/2016	NA	New			
BOD Incubator	BOD Incubator #B1	Fisher	307	90800175	1990	NA				
BOD Incubator	BOD Incubator #B4	Fisher	304	UF30K-5020/03B-868521	12/2003	NA				
BOD Incubator	BOD Incubator #B5	VWR	2020	90100	4/2007	NA				
BOD Incubator	BOD Incubator #B6	Fisher	11-679-25C	2018080603416	10/29/2012	NA				
BOD Incubator	BOD Incubator #B8	Fisher	3720	136748-668	07/16/2013	NA				
BOD Incubator	BOD Incubator #B9	Fisher	3720A	300044697	11/9/15	NA				
Drying Oven	Drying Oven #1A	Heratherm	OGS180	41385519	2012	NA				
Drying Oven	Drying Oven #3	Lindberg/BlueM	G01350C	P18G-33084-PG	1998	NA				
Centrifuge	Centrifuge #5	VWR	Clinical 200	68175027	2/7/2018	NA				
Micro Dist Hot Block	Micro Dist Hot Block #1	Lachat	Micro Dist	11010000294	8/11/2011	NA				
Micro Dist Hot Block	Micro Dist Hot Block #2	Lachat	Micro Dist A17102	141200002241	11/2014	NA	New			
Hot Block Graphite Heater	Hot Block #2	Environmental Express	ETR 3020	980826-303TS	1998	NA				
Drying Oven	Drying Oven #6	ThermoFisher Scientific	Heratherm GS180	41746692	9/1/2015	NA				
Flashpoint Tester	Flashpoint Tester #2	Koehler	K16200		4/23/13	NA				
Automated Chemistry Analyzer 3700	AA #3	O.I Analytical	329995	B550837557	01/2016	Flowview Version 1.2.1	New	Ammonia		
Automated Analyzer Autosampler	Autosampler Model 3360	O.I Analytical	ASX-520	0915907A520	01/2016	NA	New			
Automated Chemistry Analyzer 3700	AA #4	O.I Analytical	329995	B549837495	01/2016	Flowview Version 1.2.1	New	Cyanide/Nitrate/Nitrite		
Autosampler Model 3090	Autosampler Model 3090	O.I Analytical	ASX-130	111504A130	01/2016	NA	New			
TDS Static Guard	TDS Static Guard # 1	Haug	1781305	15426	11/1/2017	NA	New			
TDS Stable Weigh Filling Station	TDS Filling Station # 1	Environmental Express	TDS600F	37-7264	11/1/2017	NA	New			
		•	Microbiology	•			<u> </u>			
Incubator	Incubator #M3	Thelco	51220112	699010336	04/1999	NA				

Shealy Environmental Services, Inc.
Document Number: ME001PM-21

Effective Date: 7/16/2018

	Major Operational Equipment List											
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes				
Incubator	Incubator #M4	Thelco	51221118	604081265	8/2004	NA						
Water Bath	Water Bath #M7	Precision	2868	247358-446	4/2011	NA						
Autoclave	Autoclave #3	Market Forge	Sterilmatic	NA	05/30/2013	NA						
Black Light Lamp	Black Light Lamp #1	Spectroline	B-260	1959859	9/30/15	NA						

			Major Operational Equ	ipment List				
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes
Blender	Blender #M2	Black & Decker	PB1002	NA	08/31/2015	NA		
Water Bath	Water Bath #M8	Shel Lab	SWB2	8018015	10/8/15	NA	New	
Microscope	Microscope #2	LW Scientific	Dual Mag	HG814817	2/8/2017	NA	New	
Quanti-Tray Sealer	Quanti-Tray Sealer # 2	IDEXX	89-0003936-00	QTP13171602419	6/23/2017	NA	New	
Water Bath	Water Bath #M10	Thermo Scientific	TSCIR35	300182961	12/29/2017	NA	New	
Homgenizer	Homgenizer # 1	VWR	250	V-28-045	7/09/1905	NA	New	
7.1	D 1 //12 1224	N	Sample Receiv		101/2014	NT 4	T	T
Balance	Balance #13-1224	Mettler-Toledo	ML802E/03	B345970999	01/2014	NA		
Geiger Counter	Geiger Counter #1	Eberline Instrument Corporation	E-120E HP-190A	13618	05/2012	NA NA		
Geiger Counter Probe Survey Meter	Geiger Counter Probe #1 Survey Meter #SM-1	Thermo Scientific Ludlum Measurements Inc	HP-190A 12	305064	Unknown 10/21/14	NA NA		
-		Ludium Measurements Inc						works in conjuction
Tritium Detector, Large Area	Tritium Detector #TD-1	Ludlum Measurements Inc	44-110	PR327579	10/21/14	NA		with survey meter
	•		Semi-Volatile	s				,
GC/MS	MSD #11	Agilent Technologies	GC-6890N	CN10633016	10/2/2006	Chemstation Version		
GC/MS	MSD #11	Agnetit Technologies	MS-5975B	US53931266	10/2/2006	E.02.01.1177		
Autosampler	Autosampler #26	Agilent Technologies	7683B	CN62940495	10/2/2006	NA		
GC/MS	MSD #10	Agilent Technologies	GC-6890N	US10542069	11/2005	Chemstation Version		
GC/MB		, c	MS-5975	US53931266		E.02.02.1431		
Autosampler	Autosampler #27	Agilent Technologies	7683B	CN54028057	11/2005	NA		
GC/MS	MSD #4	Hewlett Packard	GC- 6890	US00009998	1997	Chemstation Version		
			MS- 5973	US72010678		E.02.02.1431		
Autosampler	Autosampler #28	Hewlett Packard	HP6890	US73503279	1997	NA		
GC/MS	MSD #12	Agilent Technologies	GC- 6890	CN10305019	08/2009	Chemstation Version		
		, , , , , , , , , , , , , , , , , , ,	MS- 5973	US33220170		E.02.02.1431		
Autosampler	Autosampler #29	Hewlett Packard	Series 7683	US95110869	08/2009	NA		
GC Dual ECD	GC #14	Agilent Technologies	7890B	US13463049	12/2013	Chemstation Rev C.01.05		
Autosampler	Autosampler #30	Agilent Technologies	7693	CN 13450127	12/2013	NA		
GC Dual ECD	GC #11	Agilent Technologies	6890N	CN10633092	10/2/2006	Chemstation Rev. C.01.08[210]		
Autosampler	Autosampler #31	Agilent Technologies	7683	US92107420	10/2/2006	NA		
GC Dual ECD	GC #10	Agilent Technologies	6890N	CN10518005	06/2005	Chemstation Rev. C.01.08[210]		
Autosampler	Autosampler #32	Agilent Technologies	7683B	CN51324278	06/2005	NA		
rutosampiei	Autosampier #32	righent reciniologies	7003B	CN51224274	00/2003			
GC Dual ECD	GC #7	Agilent Technologies	6890N	US10212124	2001	Chemstation Rev. C.01.08[210]		
Autosampler	Autosampler #33	Agilent Technologies	7683	US81501052	2001	NA		
GC Dual ECD	GC #5	Hewlett Packard	6890	US00022182	08/1998	Chemstation Rev. C.01.08[210]		
Autosampler	Autosampler #34	Agilent Technologies	7683	US12419286	08/1998	NA		
GC Dual FID	GC #12	Agilent Technologies	6890N	CN10650056	07/2007	Chemstation Rev. C.01.05 [35]		
Autosampler	Autosampler #35	Agilent Technologies	7683B	CN71343516	07/2007	NA		
rucosampici	2 sucosample #33	righent rechnologies	7683	US12419304	07/2007	11/1		
GC/MS	MSD #16	Agilent Technologies	GC- G3440B	US18073048	4/1/2018	Mass Hunter GC/MS Acquisition		
		J	MS- G7077B	US1807M004		B.07.06.2704		
Autosampler	Autosampler #36	Hewlett Packard	7683	US92107420	06/1999	NA		

Shealy Environmental Services, Inc. Document Number: ME001PM-21 Page 9 of 12 Effective Date: 7/16/2018

		1	Major Operational Equip	nent List				
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes
			Degasser 1200 Series	JP62357625				
	HPLC #1 A	Agilent Technologies A	Quat Pump 1200 Series	DE62959862		Cl		
HPLC			ALS 1200 Series	DE64761071	07/2007	Chemstation Rev. C.01.07[27]		
			TCC 1200 Series	DE63061942		C.01.0/[2/]		
			VWD 1200 Series	DE63058124				

·	a		Major Operational Equi		In-Service	0.0.	Condition	••
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	Date	Software Version	Received	Notes
			1260 Quat Pump	DEAB702492				
			1260 ALS	DEAB305754		Chemstation Rev.		
HPLC	HPLC #2	Agilent Technologies	1290 Thermostat	DEBAK13589	02/12/15	C.01.07[27]		
			1260 TCC	DEACN06491				
			1260 DAD	DEAA301433				
			1260 HiP Degasser (G4225A) 4465800	JPAAB07343			New	
HPLC	HPLC #3	Agilent Technologies	1260 Binary Pump (G1312B)	DEACB10794	11/1/2016	Multi Quant 3.0.2	New	
			1260 ALS (G1329B)	DEAAC42719		Version 3.0.22059.0	New	
			1260 TCC (G1316A)	DEACN45680			New	
Triple Quad Detector	MS/MS #1	Sciex	5020102	BJ29321608	11/1/2016		New	
N-EVAP 111	N-EVAP #1	Organomation	5585	61381	11/1/2016	NA	New	
Centrifuge	Centrifuge # 4	VWR International	Clinical 200	68165129	3/13/2017	NA	New	
Zero Air Generator	Zero Air Generator #2	Parker	636273003	13Z016	11/2016	NA	New	
Shaker	Shaker # 1	VWR International	3500 Std. 120V	17127011	3/14/2017	NA	New	
Sonicator	Sonicator #1	VWR International	97043-976	1717A0842	04/2017	NA	New	
Γurbo Vap LV	TurboVap LV # 1	Biotage	Turbo Vap LV	174100205	43291	NA	DEMO	
•	•	, ,	Volatiles		<u>'</u>		•	
2024	1 (GD 110		GC 6890	CN10339035	02/2004	Chemstation		
GC/MS	MSD #9	Agilent Technologies	MS 5973I	US33220060	03/2004	E.02.02.1431		
Purge & Trap Concentrator	Purge & Trap #4	OI Analytical	4660 Eclipse	D637466747P	06/2005	NA		
•			GC 6890N	US10150052		Chemstation		
GC/MS	MSD #8	Agilent Technologies	MS 5973N	US10451993	01/2002	E.02.02.1431		
Purge & Trap Concentrator	Purge & Trap #5	OI Analytical	4660 Eclipse	C504466513P	06/2005	NA		
Autosampler	Autosampler #12	OI Analytical	4551-A	F30845B199	04/2013	NA		
			GC-6890	US00034585		Chemstation		
GC/MS	MSD #7	Agilent Technologies	MS-5973N	US01150087	05/2000	E.02.02.1431		
Purge & Trap Concentrator	Purge & Trap #8	OI Analytical	4660 Eclipse	G129466450P	10/2011	NA		
Autosampler	Autosampler #13	OI Analytical	4551-A	F30845B198	04/2013	NA		
			GC 6890N	CN10508043	10/2011	Chemstation		
GC/MS	MSD #13	Agilent Technologies	MS 5973I	US44621283	10/2011	E.02.01.1177		
Purge & Trap Concentrator	Purge & Trap #2	OI Analytical	4660 Eclipse	B42546655P	10/2003	NA		
			GC 7890A	CN12071133	00/00/0	Chemstation		
GC/MS	MSD #14	Agilent Technologies	MS 5975C	US11092707	03/2012	E.02.01.1177		
Purge & Trap Concentrator	Purge & Trap #10	OI Analytical	4660 Eclipse	H301466056P	04/2013	NA		
Autosampler	Autosampler #14	OI Analytical	4551-A	F30845B200	04/2013	NA		
GC/MS	MSD #15	Agilent Technologies	GC 7890B	CN14323093	10/2014	MSD Chemstation G1701DA		
			MS 5975C	US13433B01		E.02.02.1431		
Purge & Trap Concentrator	Purge & Trap #15-1	OI Analytical	4660 (eclipse)	K433466705P	10/2014	NA		
Purge & Trap Concentrator	Purge & Trap #15-2	OI Analytical	4660 (eclipse)	K430466776P	10/2014	NA		
Autosampler	Autosampler #15-1	OI Analytical	4100	A428410167	10/2014	NA		
GC/MS	MSD #6	Agilent Technologies	GC 6890	US00032609	03/2000	Chemstation		
		- I Briefft Teelinologies	MS 5973N	US90160010	03/2000	E.02.02.1431		
Autosampler	Autosampler #3	OI Analytical	4551-A	D51945B229	06/2005	NA		
GC/MS	MSD #5	Agilent Technologies	GC 6890	US00021398	05/1998	Chemstation		
			MS 5973	US80210977		E.02.02.1431		
Purge & Trap Concentrator	Purge & Trap #3	OI Analytical	4660 Eclipse	A352466312P	02/2005	NA		
Autosampler	Autosampler #5	OI Analytical	4552	13304	02/2005	NA	1	

Page 10 of 12 Effective Date: 7/16/2018 Shealy Environmental Services, Inc.
Document Number: ME001PM-21

Effective Date: 7/16/2018

	Major Operational Equipment List														
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes							
GC PID/FID	GC #13	Agilent Technologies	GC 7890A	CN10815015		Chemstation Rev. C.01.08[210]									
Autosampler	Autosampler #4	OI Analytical	4551-A	D51045B485	06/2005	NA									
GC PID/FID	GC #9	Hewlett Packard	GC 6890N	US10403005	104/2004	Chemstation Rev. C.01.08[210]									
Headspace Autosampler	Autosampler #12	Tekmar	7000	9818007	12/2001	NA									
Autosampler	Autosampler #17	EST Analytical	LGX50	LGX116061617	7/6/2017	NA	New								

			Major Operational Equip	ment List				
Instrument / Equipment Type	Shealy ID	Manufacturer	Model	Serial Number	In-Service Date	Software Version	Condition Received	Notes
GC Dual FID	GC #8	Agilent Technologies	GC 6890	US00042711	10/2002	Chemstation Rev. C.01.08[210]		
GC Dual FID	GC #6	Hewlett Packard	GC 6890	US00026561	06/1999	Chemstation Rev. C.01.08[210]		
Autosampler	Autosampler #16	EST Analytical	LGX50	LGX11062315	08/2015	NA		
Zero Air Generator	Zero Air Generator #1	Parker	636273003	14Z0024	2015	NA	New	Part #UHP35ZASW
Hydrogen Generator	Hydrogen Generator #1	Parker	60HMD	13HMD0167	2015	NA	New	
Balance	Balance #VOA-2	Sartorius	Practum 412-1S	0032850362	5/19/15	NA	New	
Vortex Mixer	Vortex Mixer #1	Fisher Scientific	Vortex Genie 2- G-560	2-32318	Unknown	NA		Cat. No. 12-812
Purge & Trap Concentrator	Purge & Trap #17	OI Analytical	4660	C519466231	8/9/2016	NA		
Centrifuge	Centrifuge #3	VWR	Clinical 200	68145107	11/2014	NA		
Purge & Trap Concentrator	Purge & Trap #18	OI Analytical	4660	D534466729	Unknown	NA		
Purge & Trap Concentrator	Purge & Trap #19	OI Analytical	4660	A631420075	Unknown	NA		
Autosampler	Autosampler # 21	OI Analytical	4100	B508410225	Unknown	NA		
Autosampler	Autosampler # 20	OI Analytical	4100	B509410485	Unknown	NA		
Autosampler	Autosampler # 19	OI Analytical	4551-A	D34445A372	Unknown	NA		
Autosampler	Autosampler # 18	OI Analytical	4551-A	D81445B984	Unknown	NA		
•	•		Walk-in Coolers/ Refrigerat	ors/Freezers	<u> </u>			
Walk-in Cooler (SR)	Walk-in Cooler #1	Climate Control	Unknown	Unknown	Unknown	NA		
Walk-in Cooler (INM)	Walk-in Cooler #2	Bohn Refrigeration Products	ADT1300F	DSJ04042	Unknown	NA		
Walk-in Cooler (VOA)	Walk-in Cooler #8	HotPack	1208401	73160	1992	NA		
Refrigerator / Freezer (VOA)	Refrigerator / Freezer #2	Whirlpool	ET18JK	E81221051	1991	NA		
Refrigerator / Freezer (VOA)	Refrigerator / Freezer #4	General Electric	TBX18G	RT599810	03/1999	NA		
Refrigerator / Freezer (VOA)	Refrigerator / Freezer #9	Frigidaire	FRT18B4AW6	BA31031244	08/29/2003	NA		In SV Lab
Refrigerator (VOA)	Refrigerator #18	Kenmore	253.60722	WA73802498	12/2007	NA		
Refrigerator (EXT)	Refrigerator #19	Haier	HSB03-01	B2007662945	07/2007	NA		In SV Lab
Refrigerator (SV)	Refrigerator #20	Fisher Scientific	3751FS	Unknown	03/01/2013	NA		
Refrigerator (INM-Micro)	Refrigerator #21	Fisher Scientific	3751FS	145850401140716	07/23/2014	NA	New	
Freezer (VOA)	Freezer #15	Frigidaire	FFU1464FWO	WB64933778	01/2007	NA		
Freezer (EXT)	Freezer #16	Frigidaire	FFU1464FWO	WB64933777	04/02/2012	NA		
Refrigerator (SV)	Refrigerator #23	Fisher Scientific	20FREEFSA	0125428601150205	02/12/2015	NA	New	
Refrigerator (EXT)	Refrigerator #24	Fisher Scientific	20FREEFSA	0125428401150205	02/12/2015	NA	New	
Refrigerator (INM)	Refrigerator #25	Fisher Scientific	17LREEFSA	0125941501150824	08/31/2015	NA	New	
Refrigerator (SV)	Refrigerator #26	Fisher Scientific	20FREEFSA	0158496201160516	5/26/2016	NA	New	
Freezer (EXT)	Freezer #17	Fisher Scientific	20FFEEFSA	0158496401160516	5/24/2016	NA	New	
Refrigerator (SV)	Refrigerator #27	VWR	FRS-04	HS-VWR-16L730-1612	1/16/2016	NA	New	
Refrigerator (INM)	Refrigerator #28	Fisher Scientific	17LREEFSA	1162349001170307	3/15/2017	NA	New	
Freezer (VOA)	Freezer #29	Fisher Scientific	20LFEEFSA	1162790801170807		NA	New	

Page 1 of 1 Effective Date: 07/17/2018

SES Certification List

Authority	Scope	Expiration
CLP SOM02.4 Organics Contract	PCBs, Pesticides, Semivolatiles, Volatiles	10/9/2019
CLP ISM02.4 Inorganics Contract	Metals, Cyanide, Solids	10/9/2019
Delaware – DW	Drinking Water	6/30/2019
DoD ELAP/ ISO 17025	Non-Potable Water, Solid & Chemical Materials, Drinking Water	11/18/2018
DOE	NA	Approval
Kentucky - UST	NELAC	6/30/2019
Kentucky - WW	Waste Water	12/31/2018
Florida - NELAC (Primary)	Drinking Water, Non-Potable Water, Solid & Chemical Materials	6/30/2019
Georgia - NELAC (Stipulation Letter	NELAC	6/30/2019
Illinois - NELAC (Secondary)	NELAC	4/30/2019
Kansas - NELAC (Secondary)	NELAC	1/31/2019
Virginia - NELAC (Secondary)	NELAC	9/14/2018
North Carolina - WW (Lab & Field)	Waste Water (Aqueous & Solid)	12/31/2018
South Carolina	Clean Water Act, Safe Drinking Water Act, Solid & Hazardous Waste	5/12/2021

					E	QI An	alytic	al Me	thods						
	M	ethods								Mati	rix				
	Analy	sis	Prepara	ation			Aqu	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
						Inorg	anic N	lonmet	tals		ļ	!			
Alkalinity	SM2320B -2011	ME0013Z	NA		<6	14 days	NA	100mL	250mL plastic			NA	A		NA
Carbon Dioxide	SM4500-CO2D	ME0013Z	NA		<6 14 days NA 100mL 250mL plastic NA						NA				
Ammonia By Gas Diffusion	350.1	ME001GZ	NA		<6 28 days NA 100mL 250mL plastic, H2SO4 <6 28 days 24 Hrs. 10g 2 oz. glass Teflon-lined lids					NA					
BOD	SM5210B-2011	ME001ES	NA	<6 48 hrs. NA 1L 2L plastic NA					NA						
British Thermal Unit (BTU)	ASTM D2382	ME001A7	NA				N.	A		<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	Waste - same as solid
Anions By IC Br-, Cl-, F-, SO42-	300.0, 9056	ME001J3	NA		<6	28 days	NA	10mL	250mL plastic	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
Bulk Density	ASTM D5057	D5057	NA				N.	A		NA	NA	NA	10g	2 oz. glass Teflon- lined lids	NA
Chemical Oxygen Demand (COD)	SM5220D-2011	ME00145	NA		<6	28 days	NA	100mL	250mL plastic, H2SO4			NA	A		NA
TRC- Total Chlorine, Residual	SM 4500CL G- 2011	ME0016N	NA		<6	Analyze In	nmediately	100mL	250mL plastic			N.	A		NA
Hexavalent Chromium -Cr+6	SM3500-Cr B- 2011; 7196A; SW-846 Prep Method 3060A	ME001G0	NA		<6	24 Hrs.	NA	100mL	250mL plastic	<6	28 days, method 7196A	96 Hrs.	10g	2 oz. glass Teflon- lined lids	NA
Hexavalent Chromium -Cr+6	7199	ME0013B	NA		<6	24 Hrs.	NA	100mL	250mL plastic	<6	30 days	1 Week	2.5g	2 or 4 oz. glass jar	NA
Hexavalent Chromium -Cr+6	218.6	ME0013B	NA		<6	24 Hrs.	28 days	100mL	250mL plastic	<6	28 days	1 Week	2.5g	2 or 4 oz. glass jar	NA

Shealy Environmental Services, Inc. Document Number: ME002BS-02

Page 2 of 13 Effective Date: 3/2/2018

	M	ethods								Mati	rix				
	Analy	sis	Prepara	ation			Aqu	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep		Minimum Volume	Container Size, Type	Waste / Wipes & Notes
Color - Platinum Cobalt	SM2120B-2011	ME001G5	NA	<6	48 Hrs.	NA	200mL	250mL plastic			N.	A		NA	

	M	ethods								Mati	rix				
	Analy	sis	Prepara	ation			Aqu	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
Color, ADMI	SM2120E-1993	ME00146	NA		<6	48 Hrs.	NA	200mL	250mL plastic			N/	A	1	NA
Cyanide, Total and Amenable	SM4500-CN G- 2011 / SM4500- CN E-2011 / SM4500-CN C- 2011 / 335.4 / 9012B	ME0014R	NA		<6	14 days	NA	100mL	250mL plastic, NaOH	<6	14 days	NA	10g	2 oz. glass Teflon- lined lids	Waste - same as solid
Cyanide - Microdistillation	SM4500-CN E- 2011 / 10-204-00 -1-X	ME001G1	NA		<6	14 days	NA	100mL	250mL plastic, NaOH	<6 14 days NA			0.5g	2 oz. glass Teflon- lined lids	Waste - same as solid
DOC, Dissolved Organic Carbon	M5310C-2011, SW-846 9060A	ME0016Q	NA	<6	48 Hrs.	28 Days	100mL	250mL plastic	NA				NA		
Flashpoint- Ignitability Pensky- Marten	1010A	ME00192	NA		<6	ASAP	NA	50mL	250mL glass	<6	ASAP	NA	10g	2 oz. glass Teflon- lined lids	Waste - same as solid
Hardness	SM 2340C-2011	ME001ZZ	NA		<6	6 months	NA	50mL	250mL plastic, HNO3			N.	A		NA
Ferrous Iron	SM3500-Fe B- 2011	ME001G6	NA		<6	ASAP	NA	40mL	2x40mL Amber, HCl			N/	A		NA
MBAS (Methylene Blue Active Substances)	SM5540 C-2011	ME001FL	NA		<6	48 Hrs.	NA	300mL	500mL, Glass amber			N/	A		NA
Nitrate, Nitrite	353.2	ME001J4	NA		<6	48 Hrs.	NA	50mL	250mL plastic	<6	5 days	48 Hrs.	10g	2 oz. glass Teflon- lined lids	NA
Nitrate, Nitrite by IC	300.0, 9056	ME001J3	NA		<6	48 Hrs.	NA	10mL	250mL plastic	<6	5 days	48 Hrs.	10g	2 oz. glass Teflon- lined lids	NA
Nitrate + Nitrite	353.2	ME001J4	NA		<6	28 days	NA	50mL	250mL plastic, H2SO4	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
Orthophosphate	365.1	ME001J5	J5 NA <6 48 Hrs. NA 50mL 250mL plastic NA					NA							

	M	ethods								Matı	rix				
	Analy	sis	Prepara	ation			Aqu	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
Paint Filter Test	9095B	ME001CH	NA				N.	A		NA	NA	NA	50g	4 oz. glass Teflon- lined lids	NA
рН	SM4500-H B- 2011 / 9040C / 150.1 / 9041A / 9045D	ME0014S	NA		<6	ASAP	NA	50mL	250mL plastic	<6	ASAP	NA	50g	2 oz. glass Teflon- lined lids	Waste - same as solid
Phenolics	420.4, SW-846 Method 9065	ME001D2	NA		<6	28 days	NA	100mL	250mL amber glass, H2SO4	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
Phosphorus	365.1	ME001J5	NA		<6	28 days	NA	50mL	250mL plastic H2SO4	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
Reactivity (Sulfide)	SW-846 Method Guidance Section 7.3	ME001GA	NA		<6	7 days	NA	50mL	250mL plastic	<6	ASAP	NA	10g	4 oz. glass Teflon- lined lids	Waste - same as solid
Reactivity (Cyanide)	SW-846 Method Guidance Section 7.3	ME001GA	NA		<6	14 days	NA	50mL	250mL plastic	<6	ASAP	NA	10g	4 oz. glass Teflon- lined lids	Waste - same as solid
Specific Conductance	120.1, SM2510B- 2011, SM2520B- 2011	ME0017W	NA		<6	28 days	NA	50mL	250mL plastic	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
Sulfate	300.0, 9056	ME001J3	NA		<6	28 days	NA	10mL	250mL plastic	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
Sulfide	SM4500-S2 F- 2011 & EPA Method 9034 / 9030B	ME001GB	NA		<6	7 days	NA	50mL	3X250mL plastic, Zinc Acetate and NaOH	<6	7 days	NA	10g	2 oz. glass Teflon- lined lids	NA
Sulfite	SM4500 (SO3)2- B-2011	ME001MV	NA		<6	ASAP	NA	100mL	250mL plastic			NA	Α		NA
Temperature	SM2550B-2010	ME001HP	NA		Analyze Immediately 50 mL 250 mL plas			250 mL plastic	L plastic NA					NA	

	M	ethods								Mati	rix				
	Analy	sis	Prepara	ation			Aqu	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
TDS - Total Dissolved Solids	SM2540C-2011	ME0014W	NA		<6	7 days	NA	100mL	250 mL plastic			N/	A		NA
Total Halogens	9056A, 300.0	ME001J3	NA		<6	28 days	NA	50mL	250mL plastic	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
TKN - Total Kjeldahl Nitrogen	351.2	ME001BI	NA		<6	28 days	NA	50mL	250mL plastic H2SO4	<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
TIC - Total Inorganic Carbon	SM5310C-2011 and SW-846 9060A	ME0016Q	NA		<6	28 days	NA	50mL	250mL plastic H2SO4		NA				NA
TOC - Total Organic Carbon	SM5310C-2011 and SW-846 9060A	ME0016Q	NA		<6	28 days	NA	50mL	250mL plastic H2SO4	NA				NA	
TOC - Total Organic Carbon	Walkley-Black	ME001BG	NA				N.	A		<6	28 days	NA	10g	2 oz. glass Teflon- lined lids	NA
TS - Total Solids	SM2540B-2011 / SM2540E-2011 / EPA Method 160.4 / SM2540G -1997	ME0014Y	NA		<6	7 days	NA	100mL	250 mL plastic			NA	A		NA
TSS - Total Suspended Solids	SM2540D-2011	ME0014X	NA		<6	7 days	NA	1000mL	2L plastic			N/	A		NA
Tubidity	180.1	ME001HW	NA		<6	48 hrs.	NA	50mL	250 mL plastic	ic NA			NA		
TVS - Total Volatile Solid	SM2540B-2011 / SM2540E-2011 / EPA Method 160.4 / SM2540G -1997	ME0014Y	NA		<6	7 days	NA	100mL	250 mL plastic	ic NA			NA		

	M	ethods								Matı	rix				
	Analy	ysis	Prepara	ation			Aqu	eous				Sol	lid		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
							Met	als							
Metals (excludes Hg)	200.8, 6020B	(200.8) ME0017U (6020B) ME001FI	200.2, 200.7/3005A, SM3030C, 3050B	ME001HA, ME001IB, ME001IF, ME001J7	NA	6 months	NA	100mL	250 mL plastic HNO3	NA	6 months	NA	10g	2 oz. glass Teflon- lined lids	Waste - same as solid
Metals (excludes Hg)	200.7, 6010D	(200.7) ME0017T (6010D) ME001FJ	200.7/3005A, 3010A, SM3030C, 3050B	ME001IB, ME001H8, ME001IF, ME001J7	NA	6 months	NA	100mL	250 mL plastic HNO3	NA	6 months	NA	10g	2 oz. glass Teflon- lined lids	Waste - same as solid
Mercury (CVAA)	7470A	ME0017R	245.1, 7470A	ME00II	NA	28 days	NA	100mL	250 mL plastic HNO3			N.	A		NA
Mercury (CVAA)	7471B	ME0017R	245.5, 7471B	ME001J6			N.	A		<6	6 months	NA	10g	2 oz. glass Teflon- lined lids	Waste - same as solid
Mercury (CVAFS)	1631E	ME0017X	NA		NA 28 days NA 40mL 3 x 40 mL glass, certified Hg-free VOA vials with Teflon-lined septa no headspace				NA						

	Methods									Matı	rix				
	Analy	sis	Prepara	ation			Aqu	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
							Orga	nics							
EDB /DBCP	8011	ME00187	NA		<6	14 days	NA	40mL	3x40mL, HCl glass VOA			N.A	A		NA
EDB /DBCP	504.1	ME00187	NA		<6	14 days	NA	40mL	3x40mL, Sodium thiosulfate glass VOA	NA				NA	
Explosives	8330A, 8330B	ME001R4	3535A	ME001R4	<6	7 days	40 days	1L	2x1L amber glass Teflon-lined lid	<6	14 days	40 days	50g	4 oz. glass Teflon- lined lids	NA
Herbicides	8151	ME00157	8151	ME001IM	<6	7 days	40 days	1L	2x1L amber glass Teflon-lined lid	<6	14 days	40 days	50g	4 oz. glass Teflon- lined lids	Waste - same as solid
Pesticides/ PCBs	608; SW-846 Methods 8081B and 8082A	ME0019A	3520C, 3580A, 3550C, and 3546	ME00155, ME00150, ME00154, and ME00156	<6	7 days	40 days	1L	2x250mL amber glass Teflon-lined lid	<6	14 days	40 days	50g	4 oz. glass Teflon- lined lids	Waste - same as solid
Petroleum Hydro- carbons/ Oil & Grease (Hexane Extractable Material)	1664B	ME0014T	NA		<6	28 days	NA	1L	1L widemouth glass			N/	A		NA
Petroleum Hydro- carbons/ Oil & Grease (Hexane Extractable Material)	9071B	ME001IO	NA			NA				<6	28 days		100g	4 oz. glass Teflon- lined lids	NA
Per- & Polyfluorinated Alkyl Substances	537	ME00213	NA	<6	14 days	28 days	250 mL	250 mL polypropylene, TRIZMA			N.A	A		NA	
Per- & Polyfluorinated Alkyl Substances	537 Mod	ME00213	NA		<6	14 days	28 days	250 mL	250 mL polypropylene	<6	14 days	28 days	10g	2 oz. glass Teflon- lined lids	NA

	Methods					Matrix									
	Analy	sis	Prepara	ation	Aqueous							Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
Per- & Polyfluorinated Alkyl Substances	537 Mod Dilute & Shoot	ME00213	NA		<6	14 days	28 days	8 mL	250 mL polypropylene	NA			NA		
SVOC	8270D	ME0014Q	3520C , 3546, 3550C , 3510C, 3540C and 3580A	ME00155, ME0156, ME00154, ME0011Z, ME001LX, and ME00150	<6	7 days	40 days	250mL	2x250mL amber glass Teflon-lined lid	<6	14 days	40 days	50	4 oz. glass Teflon- lined lids	Waste - same as solid
SVOC	625	ME0014Q	3520C , 3546, 3550C , 3510C, 3540C and 3580A	ME00155, ME0156, ME00154, ME0011Z, ME001LX, and ME00150	<6	7 days	40 days	250mL	2x250mL amber glass Teflon-lined lid Sodium Thiosulfate if chlorinated			N/	A		NA
DRO	8015C	ME00138	3520C, 3546, 3550C and 3580A	ME00155, ME00156, ME00154, and ME00150	<6	7 days	40 days	250mL	2x250mL HCl amber glass Teflon- lined lid	<6	14 days	40 days	50	4 oz. glass Teflon- lined lids	Waste - same as solid
Fl-Pro	FLO-PRO / 3520C & 3550B	ME001IQ	3520C and 3550B	ME00155 and ME00154	<6	7 days	40 days	1L	2x1L HCl amber glass Teflon-lined lid	<6	14 days	40 days	50	4 oz. glass Teflon- lined lids	Waste - same as solid
ЕРН	MADEP-EPH-04	ME001J1	MADEP-EPH-04	ME001IN	<6	14 days	40 days	1L	2x1L HCl amber glass Teflon-lined lid	<6	14 days	40 days	50	4 oz. glass Teflon- lined lids	Waste - same as solid
GRO	8015C	ME00137	EPA 5030B and 358	ME00137	<6	14 days	NA	40mL	3x40mL, HCl glass VOA	<6	14 days	NA	10g	2 x 5g Encore samplers, or 2 x 40 mL pre-weighed VOA vials with 5mL methanol	Waste - same as solid

	Methods					Matrix									
	Analy	sis	Prepara	ation			Aque	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
VPH	MADEP-VPH- 04	ME00136	MADEP-VPH-04	ME00136	<6	14 days	NA	40mL	3x40mL, HCl glass VOA	<6	28 days	NA	10g	2 x 5g Encore samplers, or 2 x 40 mL pre-weighed VOA vials with 5.0 mL of methanol	waste - saine as
Glycols	8015C	ME001FZ	NA		<6	14 days	NA	40mL	3x40mL, HCl glass VOA	<6	14 days	NA	50g	4 oz. glass Teflon- lined lids	NA
Alcohols	8015C	ME001FZ	NA		<6	14 days	NA	40mL	3x40mL, HCl glass VOA	<6	14 days	28 days	50g	4 oz. glass Teflon- lined lids	NA
VOC	8260B, 624, 6200B- 2011	ME0012X	NA		<6	14 days, 7 days if no HCl	NA	40mL	3 x 40 mL glass VOA vial, Teflon- lined septa with 5mL HCl no headspace. Sod. Thiosulfate if chlorinated	<6	14 days	NA	15g	5035 Kit (2 x 40 mL pre-weighed vials containing reagent water and stir bar. 1x40 mL pre-weighed vial with 5 mL methanol, and one 40mL VOA. Or 3x5g Encore	2 oz. glass Teflon -lined lids
VOC	524.2	ME001HI	NA		<6	14 days	NA	40mL	3 x 40 mL glass VOA vial, Teflon- lined septa with 5mL HCl no headspace. Sod. Thiosulfate if chlorinated			NA			NA
Dissolved Gasses (Methane, Ethane, and Ethene)	RSK-175	ME00139	NA		<6	14 days	NA	40mL	3 x 40 mL glass VOA vial, Teflon- lined septa with 5mL HCl no headspace. Sod. Thiosulfate if chlorinated		NA N			NA	

	Methods				Matrix										
	Anal	ysis	Prepar	ation			Aque	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
						I	SM/S	SOM						<u> </u>	
voc	SOM02.4	Low/Med ME001E3 Trace ME001E2	NA		<10	NA	10 days from VTSR	40mL	3x 40 mL glass VOA vial, Teflon- lined septa with 5mL HCl no headspace. Sod. Thiosulfate if chlorinated	<10	10 days from VTSR	NA	5g	for Low level: 40 mL pre-weighed closed-system vial 5mL DI H2O and 1 MeOH; can be 3 x 5g vials with stirbar	NA
SVOC	SOM02.4	ME001E1	SOM02.4	Ultrasonic ME001DT, Liq-Liq ME001DU	<10	5 days from VTSR	40 days	1L	1 L amber glass containers fitted with PFTE- lined screw caps	<10	10 days from VTSR	40 days	100g	4 oz. glass Teflon- lined lids	NA
Pesticides/PCBs	SOM02.4	(PCB) ME001NS (Pest) ME001NT	SOM02.4	Ultrasonic ME001DT, Sep Funnel ME001DW, Liq-Liq ME001DU, Cleanup ME001DV	<10	5 days from VTSR	40 days	1L	1 L amber glass containers fitted with PFTE- lined screw caps	<10	10 days from VTSR	40 days	100g	4 oz. glass Teflon- lined lids	NA
TCLP/SPLP Herbicides	SOM02.4	ME0019C	Please see analy SOPs for each in		<10	5 days from VTSR	7 days	1L	1x1L Amber glass	<10	10 days from VTSR	7 days	100g	9 oz. Glass	Waste - same as solid
ZHE Volatiles with ≥ 0.5% solid	SOM02.4	ME0019C	Please see analy SOPs for each ir					NA		<10	10 days from VTSR	7 days	40mL	40 mL PTFE- lined septum capped vials.	NA
TCLP/SPLP Non- Volatiles or Waste Containing ≤ 0.5% solid	SOM02.4	ME0019C	Please see analy SOPs for each in		<10	5 days from VTSR	7 days	1L	1 L amber glass containers fitted with PFTE- lined screw caps	<10	10 days from VTSR	7 days	100g	4 oz. glass Teflon- lined lids	NA
Metals	ISM02.4	(ICP) ME0013K and (ICPMS) ME001DZ	NA		<10	NA	180 days from VTSR	100 mL	Glass or polyethylene containers Preserved with Nitric Acid to a pH of ≤ 2	<10	NA	180 day from VTSR	1.0g	Glass or polyethylene containers Preserved with Nitric Acid to a pH of ≤ 2	NA

Shealy Environmental Services, Inc. Document Number: ME002BS-02

	Methods					Matrix									
	Anal	ysis	Prepara	ation			Aque	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
Mercury	ISM02.4	ME0013G	NA		<10	NA	26 days from VTSR	100 mL	Glass or polyethylene containers Preserved with Nitric Acid to a pH of ≤ 2	<10	26 day from VTSR	NA	0.5g	Glass or polyethylene containers Preserved with Nitric Acid to a pH of ≤ 2	NA
ICP-AES/ ICP-MS (TCLP/SPLP)	ISM02.4	ME0019C	Please see analy SOPs for each in	rsis and prep ndividual test			N.	A		<10	NA	180 day from VTSR	100g	Preserved with Nitric Acid to a pH of ≤ 2. Store at ≤ 6°C but not frozen. Holding time is 180 days from extraction.	NA
Mercury (TCLP/SPLP)	ISM02.4	ME0019C	Please see analy SOPs for each in	rsis and prep ndividual test		NA			<10	26 day from VTSR	NA	100g	Preserved with Nitric Acid to a pH of ≤ 2. Store at ≤ 6°C but not frozen. Holding time is 180 days from extraction.	NA	
Cyanide	ISM02.4	ME001E0	NA		<10	NA	12 days from VTSR	50mL	Polyethylene or glass containers, Sodium hydroxide to a pH ≥ 10	<10	NA	12 days from VTSR	1g	Polyethylene or glass containers NaOH pH > 12	NA
SPLP Cyanide	ISM02.4	ME0019C	Please see analy SOPs for each in				N	A		<10	NA	12 days from VTSR	1g	Polyethylene or glass containers	NA

	Methods									Matı	ix				
	Analy	sis	Prepara	ation			Aqu	eous				Sol	id		
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Waste / Wipes & Notes
					!!	T(CLP/	SPLP		ı					
TCLP and SPLP VOC and SVOC (BNAs, Pesticides, Herbicides)	Leach by TCLP/SPLP Method 1311/1312	ME0019C	Please see analy SOPs for each in		<6	14 days	7 days	1L	1x1L Amber glass	<6	14 days	7 days	100g	9 oz. Glass	Waste - same as solid
TCLP and SPLP Metals (except Mercury)	Leach by TCLP/SPLP Method 1311/1312	ME0019C	Please see analy SOPs for each in		<6	180 days	NA	1L	1x1L Amber glass	<6	180 days	NA	100g	9 oz. Glass	Waste - same as solid
TCLP and SPLP Mercury	Leach by TCLP/SPLP Method 1311/1312	ME0019C	Please see analy SOPs for each in		<6	28 days	NA	1L	1x1L Amber glass	<6	28 days	NA	100g	9 oz. Glass	Waste - same as solid
						Mi	crobio	logica							
Fecal Coliform	Colilert-18 ATP	ME001BL	NA		4 ± 2°C	8 Hrs.	NA	100mL	Sterile 100 mL plastic, preserved with Sodium thiosulfate			N/	A		NA
Total Coliform	SM 9223B-2004	ME0014Z	NA		4 ± 2°C	30 Hrs.	NA	100mL	Sterile120 mL plastic, preserved with Sodium thiosulfate			N/	A		NA
Heterotrophic Plate Count	SimPlate	ME001J0	NA	NA		8 Hrs.	NA	100mL	Sterile120 mL plastic, preserved with Sodium thiosulfate		NA			NA	
Fecal Coliform (MF)	SM 9222D-1997	ME0014U	NA		4 ± 2°C	8 Hrs.	NA	250mL	Sterile250 mL plastic, preserved with Sodium thiosulfate	NA		A		NA	
Fecal Coliform (MPN)	SM 9221C E- 2006	ME00143	NA				N.	A		4 ± 2°C		NA	10g	Sterile120 mL plastic, preserved with Sodium thiosulfate	NA

Shealy Environmental Services, Inc. Document Number: ME002BS-02

Page 13 of 13 Effective Date: 3/2/2018

	Methods					Matrix									
	Analy	/sis	Prepara	ation		Aqueous Solid									
Analytical Parameter	Method	SOP#	Method	SOP#	Temp Required (°C)	Holding Time Collection to Prep	Holding Time Prep to Analysis	Minimum Volume	Container Size, Type	Temp Required (°C)	Holding Time Collection to Prep		Minimum Volume	Container Size, Type	Waste / Wipes & Notes
E. Coli (MPN)	SM 9223B-2004 (by Colilert-18)	ME001BL	NA		4 ± 2°C	8 Hrs.	NA	100mL	Sterile250 mL plastic, preserved with Sodium thiosulfate			NA	A		NA



Execution Time 7/17/2018 11:02

Policies - Administrative	
Employee Handbook [Formerly P-AD-001 Rev 4]	ME002CW-01
Ethics Policy Agreement	ME0012V-07
Project Management	ME001HD-05
Policies - Health and Safety	
Elementary Neutralization Procedure	ME001OU-02
Emergency Procedures	ME00189-05
Health and Safety Committee	ME001I2-01
Medical Procedures	ME00188-04
Return of Electron Capture Detectors	ME001I5-01
Spill Clean-up Procedures	ME001O1-03
Vistor Environmental Health and Safety Briefing	ME0024I-03
Waste Accumulation Building Emergency Plan	ME0018B-03
Policies - Quality Assurance	
CLP Data Package Generation, Assembly and Review [SOW SOM02.4 & ISM02.4]	ME0013C-04
Data Package Generation, Assembly and Review [Level 3 & Level 4]	ME001QX-01
Glassware Washing	ME001IV-02
Limit of Detection (LOD) and Limit of Quantitation (LOQ) Determination and Verification	ME001F1-01
Management Review	ME001HH-02
Annual Integration Practices	ME001HC-01
Method Detection and Quantitation Limits	ME001WR-01
Solvent Purity Check	ME001J8-01
Trend Analysis of Data Using Control Charts	ME001IW-01
QAMP - Quality Assurance	
Quality Assurance Management Plan [(QAMP)]	ME0012K-06
SOPs - Administration	
Laboratory Information Management System (LIMS)	ME00161-05
LIMS User Guide	ME001IS-03
Procurement of Laboratory Supplies, Services and Equipment	ME0015U-04
Sample Container Shipping	ME001DS-03
Sample Receiving	ME0013H-08
SOPs - BOD/Micro	
Biochemical Oxygen Demand (BOD) and Carbonaceous Biochemical Oxygen Demand (CBOD) [SM5210B-2011 5 Days at 20 C/ Hach 10360 Rev 1.2]	ME001ES-06
Fecal Coliform (Membrane Filter) [SM9222D-2006]	ME0014U-04

Shealy Environmental

106 Vantage Point Drive, West Columbia, SC 29172 Phone: (803) 791-9700 Fax: (803) 791-9111



Execution Time 7/17/2018 11:02

Fecal Coliform (Most Probable Number) [SM9221B.1-2006 / SM9221C.2-2006 / SM9221E.1-2006 with Biosolids Preparation EPA 625/R-92/013 App. F]	ME00143-04
Fecal Coliform and E. Coli Analysis by Enzyme Substrate Testing [Colilert-18 and SM 9223B-2004]	ME001BL-03
Media, Reagents and Supplies Quality Control [SM 9020 (2005); SM 9030 (2006); SM 9040 (2006); SM 9050 (2006)]	ME0016R-06
Standard Plate Count (Heterotrophic Plate Count) [IDEXX Simplate Method]	ME001J0-02
Thermotolerant (Fecal) Coliform Determination in Sewage Sludge by Membrane Filtration [SM 9222 D-2006 with Biosolids Preparation EPA 625/R-92/013 Appendix F]	ME002L8-03
Total Coliform (Colilert-18) [SM9223 B-2004]	ME0014Z-03
SOPs - Extractions	
Continuous Liquid-Liquid Extraction [Method 3520C]	ME00155-04
Continuous Liquid-Liquid Extraction of Semivolatiles [CLP SOW SOM02.4]	ME001DU-03
Extraction of Chlorinated Herbicides [Method 8151A]	ME001IM-03
Hexane Extractable Material (HEM) and Silica Gel Treated Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry [EPA Method 1664B]	ME0014T-03
Microwave Extraction [SW-846 Method 3546]	ME00156-05
n-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel HEM (SGT-HEM) for Solid Samples [EPA Method 9071B]	ME001IO-03
Sample Preparation for the Determination of Extractable Petroleum Hydrocarbons (EPH) [MADEP-EPH-04]	ME001IN-03
Semivolatile Cleanup Procedures - Florisil, Silica Gel, GPC, Sulfur & Sulfuric Acid [CLP SOW SOM02.4]	ME001DV-03
Separatory Funnel Liquid-Liquid Extraction [Method 3510C]	ME001IZ-03
Separatory Funnel Liquid-Liquid Extraction of Pesticides and Aroclors [CLP SOW SOM02.4]	ME001DW-03
Soxhlet Extraction [Method 3540C]	ME001LX-03
Synthetic Precipitation Leaching Procedure (SPLP) [EPA Method 1312]	ME001IY-03
Toxicity Characteristic Leaching Procedure [EPA Method 1311 / ISM02.4 / SOM02.4]	ME0019C-04
Ultrasonic Extraction [Method 3550C]	ME00154-06
Ultrasonic Extraction of BNAs, Pesticides and Aroclors [CLP SOW SOM02.4]	ME001DT-03
Waste Dilution Method [Method 3580A for Analytical Methods 8270, 8015, FL-PRO and 8082]	ME00150-04
SOPs - Field Services	
Field Analysis of Dissolved Oxygen (Membrane Electrode) [SM4500-O G-2011]	ME001HV-03
Field Analysis of pH [SM4500-H+ B-2011]	ME0012L-06
Field Analysis of Specific Conductance [EPA Method 120.1]	ME0012M-05
Field Analysis of Temperature (Thermometric Method) [SM2550B-2010]	ME001HP-02
Field Analysis of Total Residual Chlorine (DPD Colorimetric Method) and Trace Level Total Residula Chlorine (DPD Spectrophotometric Method) [SM 4500Cl G-2011]	ME001HQ-03
Field Services	ME001BS-03
Field Services Short-Hold Reporting	ME001IT-02

Shealy Environmental

106 Vantage Point Drive, West Columbia, SC 29172 Phone: (803) 791-9700 Fax: (803) 791-9111



Execution Time 7/17/2018 11:02

Sampling Ambient Water for Low Level Mercury [EPA Method 1669 / Analysis by EPA Method 1631E] ME001IH-03 **SOPs - Health and Safety** Comprehensive Chemical Hygiene, Safety and Hazard Communication Plan ME0012D-07 **Destruction and Disposal of Empty Sample Containers** ME001H7-03 **Emergency Preparedness Plan** ME0012B-06 Foreign Soil and Regulated Domestic Soil Sample Receiving, Laboratory Handling, Disposal and ME001J9-02 **Documentation Fume Hood Inspection** ME001AE-03 Hazardous and Non-Hazardous Laboratory Waste Management Plan ME0012A-06 **Integrated Contingency Plan** ME0012C-06 Lockout / Tagout ME001I3-03 **Radiation Safety Plan** ME001I4-03 **Respiratory Protection Plan** ME001I1-03 **SOPs - Inorganic Metals** Acid Digestion Methods for Total Recoverable Metal Analysis by ICP-MS [Methods 200.2 & 3005A] ME001HA-03 Acid Digestion of Aqueous Samples and TCLP/SPLP Extracts for Total Metals Analysis by ICP and ME001H8-03 ICP-MS Spectroscopy [Method 3010A] Acid Digestion of Aqueous Samples for Total Recoverable Metals Analysis by ICP Spectroscopy [SM ME001IF-03 3030Cl Acid Digestion of Aqueous Samples for Total Recoverable Metals Analysis by ICP-AES Spectroscopy ME001IB-03 [Method 200.7 / 3005A] Acid Digestion of Sediments, Sludges and Soils [Method 3050B] ME001J7-07 Analytical Method for Inductively Coupled Plasma - Atomic Emission Spectroscopy [CLP SOW ME0013K-04 **ISM02.4**] Digestion of Aqueous Samples and TCLP/SPLP Extracts for Mercury Analysis by Cold-Vapor Atomic ME001II-03 Absorption Spectroscopy [Method 245.1 / 7470A] Digestion of Solid and Semisolid Wastes for Mercury Analysis by Cold-Vapor Atomic Absorption ME001J6-03 [Method 245.5 / 7471B] Inductively Coupled Plasma - Atomic Emission Spectroscopy [Method 6010D] ME001FJ-05 Inductively Coupled Plasma - Atomic Emission Spectroscopy for Trace Element Analysis [Method ME001J2-03 6010Cl Inductively Coupled Plasma - Atomic Emission Spectroscopy Spectrometric Method for Trace Element ME0017T-04 Analyses [Method 200.7] Inductively Coupled Plasma - Mass Spectrometry [Method 6020B] ME001FI-05 Inductively Coupled Plasma - Mass Spectrometry [Method 6020A] ME00147-04 Inductively Coupled Plasma - Mass Spectrometry [CLP SOW ISM02.4] ME001DZ-04 **Inductively Coupled Plasma - Mass Spectrometry Analysis [Method 200.8]** ME0017U-04 Mercury Analysis by Cold-Vapor Atomic Absorption [Methods 245.1 / 7470A and 7471B] ME0017R-04 Preparation and Analysis of Mercury for Aqueous and Solid Samples by Cold-Vapor Atomic ME0013G-05 **Absorption [CLP SOW ISM02.4]**

Shealy Environmental

106 Vantage Point Drive, West Columbia, SC 29172 Phone: (803) 791-9700 Fax: (803) 791-9111



Execution Time 7/17/2018 11:02

ME0017X-05

Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Fluorescence [Method 1631E]

SOPs - Inorganic Non-Metals	
Acidity by Titration [SM2310B-2011]	ME001G4-03
Alkalinity by Titration, Carbon Dioxide and Alkalinity by Calculation [SM2320B-2011, SM4500-CO2D, Client Specific Alkalinity & Volatile Acids]	ME0013Z-05
Ammonia Nitrogen by Gas Diffusion Segmented Flow Analysis [EPA Method 350.1]	ME001GZ-04
Analysis of Sulfite by Titration [SM4500 (SO3)2- B-2011]	ME001IX-03
Anionic Surfactants as Methylene Blue Activated Substances (MBAS) by Colorimetric Determination [SM5540C-2011]	ME00135-04
Bomb Preparation Method for Solid Waste and Non-Aqueous Liquids [SW-846 Method 5050]	ME001G2-03
BTU / Heat of Combustion [ASTM Method D2382]	ME001A7-03
Calcium Hardness (as mg/L CaCO3) by EDTA Titration [SM3500-Ca B-2011 / SM3030E-2011]	ME0017P-03
Chemical Oxygen Demand (COD) [SM 5220 D-2011]	ME00145-05
Chlorine, Total Residual by Spectrophotometric Analysis [SM 4500Cl G-2011]	ME0014V-04
Color, ADMI [SM2120 F-2011]	ME00146-04
Conductance, Specific Conductance, Conductivity and Salinity [EPA Method 120.1, SM2510 B-2011, SM2520 B-2011]	ME0017W-03
Cyanide, Total and Amenable by Automated Spectrophotometric Analysis [SM4500-CN B-2011 / SM4500-CN C-2011 / SM4500-CN G-2011 / SM4500-CN G-2011 / 335.4 / 9012B]	ME0014R-04
Cyanide, Total by Automated Spectrophotometry with Microdistillation [10-204-00-1-X / SM4500-CN E -2011]	ME001G1-03
Determination of Total Recoverable Phenolics by Automated 4-AAP Flow Injection Analysis [EPA Method 420.4 and SW-846 Method 9065]	ME001D2-03
Ferrous Iron (Phenanthroline Method) and Ferric Iron by Calculation [SM3500-Fe B-2011]	ME001G6-03
Hexavalent Chromium by Colorimetric Spectrophotometry Using Discrete and Manual Analysis [SM3500-Cr B-2011; 7196A; SW-846 Prep Method 3060A]	ME001G0-03
Hexavalent Chromium by Ion Chromatography [EPA 7199 and 218.6 SW-846 Prep Method 3060A]	ME0013B-04
Ignitability (Flash Point) by Pensky-Marten Closed Cup Tester [Method 1010 / 1010A]	ME0017K-04
Inorganic Anions by Ion Chromatography [EPA Method 300.0 / SW-846 9056A]	ME001J3-04
Luminescence Measurement of Dissolved Oxygen [Hach Method 10360 Rev 1.2]	ME001EQ-04
Nitrate-Nitrite, Nitrate, and Nitrite Nitrogen Analysis [EPA Method 353.2]	ME001J4-03
Nonionic Surfactants as Cobalt Thiocyanate Active Substances (CTAS) by Colorimetric Determination [SM5540D-2011]	ME001HY-02
Paint Filter Liquids Test [Method 9095B]	ME001CH-03
Percent Solid and Percent Moisture in Solid and Semisolids [SM2540G-2011, ISM/SOM02.4, EPA 160.3]	ME0013F-04
pH by Electrometric Measurement / pH Paper Method [SM4500-H B-2011 / 9040C / 150.1 / 9041A / 9045D]	ME0014S-05
Preparation and Analysis of Total Cyanide [CLP SOW ISM02.4]	ME001E0-04
Reactivity - Reactive Cyanide and Reactive Sulfide [SW-846 Method Guidance Section 7.3]	ME001GA-03

Shealy Environmental

106 Vantage Point Drive, West Columbia, SC 29172 Phone: (803) 791-9700 Fax: (803) 791-9111



Execution Time 7/17/2018 11:02

Sulfide by Titration [SM4500-S2 F-2011 & El	PA Method 9034 / 9030B]	ME001GB-03
Temperature (Thermometric) [SM2550B-201	0 / SM2550B-2000]	ME001HR-03
Total Dissolved Solids (TDS) [SM 2540 C-201	1]	ME002HM-03
Total Hardness as mg CaCO3/L by EDTA Ti / SM2340B-2011]	trimetric Method and Calculation Method [SM2340C-2011	ME001H5-03
Total Kjeldahl Nitrogen (TKN) by Flow Injec	ction Analysis Colorimetry [Method 351.2]	ME002SR-01
Total Organic Carbon (TOC) [Walkley-Black	c]	ME001BG-03
Total Organic Carbon (TOC) [SM5310C-201	1 and SW-846 9060A]	ME0016Q-03
Total Phosphorous and Orthophosphate by C 365.1]	Colorimetric Automated Discrete Analyzer [EPA Method	ME001J5-03
Total Solid (TS), Total Volatile Solid (TVS) a / EPA Method 160.4 / SM2540G-1997]	nd Percent Volatile Solid [SM2540B-2011 / SM2540E-2011	ME0014Y-03
Total Suspended Solid (TSS) and Total Volat 160.4]	ile Suspended Solid (TVSS) [SM2540D-2011 / EPA Method	ME0014X-06
True Color - Platinum Cobalt [SM 2120 B-20	11]	ME001G5-03
Turbidity by Nephelometry [Method 180.1]		ME001HW-03
Usable Fiber Loss [International Paper]		ME001UD-02
	SOPs - PFAS	
Determination of Per- and Polyfluoroalkyl Su	ubstances (PFAS) by LC/MS/MS [EPA Method 537]	ME002I6-02
Determination of Per- and Polyfluoroalkyl Su Injection) [EPA 537 MOD DAI]	ubstances (PFAS) by LC/MS/MS (Direct Aqueous	ME002I7-01
Determination of Per- and Polyfluoroalkyl Su 5.1 Table B-15 (EPA 537 MOD ID)]	ubstances (PFAS) by LC/MS/MS (Isotope Dilution) [QSM	ME00213-08
SO	Ps - Quality Assurance	
Deionized Water System and Storage Blank	resting	ME0012S-06
Demonstration of Capability [IDOC / CDOC]	l	ME001F2-05
Document Control		ME001HX-04
Equipment and Instrumentation		ME002JT-01
Internal Audits & QSM Data Report Review		ME0015T-04
Logbook and Data Recording		ME0012T-07
Non-Conformances, Corrective and Preventionand Services [NCM, CAPA, Client Complain	ve Actions, Client Complaints, and Nonconforming Items t, NIS]	ME001BO-04
Performance Evaluation / Proficiency Testing	;	ME001IG-03
Preparation and Documentation of Laborato	ry Standards and Reagents	ME001HG-05
Records Management		ME001ID-03
Solid Sample Sub-sampling for Analytical Pr	eparation	ME001IU-03
Spreadsheet Validation		ME001IJ-03
S	SOPs - Semi-Volatiles	

Shealy Environmental 106 Vantage Point Drive, West Columbia, SC 29172 Phone: (803) 791-9700 Fax: (803) 791-9111



Execution Time 7/17/2018 11:02

Determination of Extractable Petroleum Hydrocarbons (EPH) [MADEP-E	EPH-04 Modified Method] ME001J1-03
Diesel Range Organics (DRO) by GC/FID Analysis [Method 8015C / Prepa 3550C and 3580A]	mared by EPA 3520C, 3546, ME00138-05
Explosives by High Performance Liquid Chromatography (HPLC) [SCDH and 8332]	HEC - EPA Methods 8330A ME0018E-04
Explosives by HPLC [EPA Method 8330A]	ME001JB-03
Gas Chromatographic Analysis of Aroclors [CLP SOW SOM02.4]	ME001NS-03
Gas Chromatographic Analysis of Pesticides [CLP SOW SOM02.4]	ME001NT-03
GC / ECD Analysis of EDB and DBCP [Methods 8011 and 504.1]	ME00187-03
GC-FID Petroleum Range Organics Analysis [FLO-PRO / 3520C & 3550E	ME001IQ-03
GC-MS Semivolatile Analysis [CLP SOW SOM02.4]	ME001E1-03
Herbicides by Gas Chromatographic Analysis [EPA SW-846 Method 8151	ME00157-06
Nitroaromatics, Nitramines, and Nitrate Esters by HPLC [EPA Method 83 8330B Soil Preparation]	330B by 3535A and Modified ME001R4-04
Pesticides and PCBs by Gas Chromatographic Analysis [EPA 608.3; SW-88082A]	846 Methods 8081B and ME0019A-05
Semivolatiles by GC/MS Analysis [EPA Methods 8270D / 625.1; Prepared 3546, 3550C, 3510C, 3540C and 3580A] $$	by EPA Methods 3520C, ME0014Q-09
SOPs - Volatiles	
Alcohols and Glycols by Direct Aqueous Injection GC/FID [Method 80150	C] ME001FZ-04
Determination of Volatile Petroleum Hydrocarbons (VPH) by Purge & Tr VPH-18-2.1]	rap GC/PID-FID [MADEP- ME00136-04
Gasoline Range Organics (GRO) by GC/FID Analysis [Method 8015C / EI	PA 5030B and 3585] ME00137-05
GC Analysis of Dissolved Gases [RSK-175]	ME00139-04
GC-MS Low/Medium Volatile Analysis [CLP SOW SOM02.4]	ME001E3-04
GC-MS Trace Volatile Analysis [CLP SOW SOM02.4]	ME001E2-04
GC/MS Volatiles Analysis [Methods 8260B/C, 624.1 and SM6200B-2011]	ME0012X-12
Measurement of Purgeable Organic Compounds in Water by Gas Chroma Spectrometry [Method 524.2]	atography - Mass ME001HI-05

SHEALY ENVIRONMENTAL SERVICES, INC.

STANDARD OPERATING PROCEDURE

Sample Receiving

5/5/2018 6:41:59 PM

Daniel Wright

Robert The

Daniel J. Wright

Laboratory Director

5/4/2018 1:48:58 PM

Wendy Plessinger

Quality Assurance Officer

Bradle Billi

Wardy Plessing

5/7/2018 9:07:37 AM

Robert Zhu

Technical Director

5/7/2018 9:09:02 AM

Bradley E. Belding

Operations Director

5/7/2018 3:04:26 PM Eleanor C. Cuaresma

acon.

Group Leader

Proprietary Information Statement:

This document has been prepared by and remains the sole property of Shealy Environmental Services, Inc. It is submitted to a client or government agency solely for its use in evaluating Shealy's qualifications in connection with the particular project, certification, or approval for which it was prepared. This document is to be held proprietary to Shealy.

The user agrees by its acceptance or use of this document to return it upon Shealy's request and to not reproduce, copy, lend, or otherwise disclose or dispose of the contents, directly or indirectly. The user also agrees to not use it for any purpose other than that for which it was specifically furnished. The user agrees that access to this document shall not be given to consultants or others outside of the user's organization when those parties are involved in the evaluation process, unless those parties also specifically agree to these conditions.

Shealy Environmental Services, Inc. Document Number: ME0013H-08

TABLE OF CONTENTS

1.	PURPOSE	3
2.	RESPONSIBILITIES	3
3.	SAFETY	3
4.	PROCEDURE	5
5.	REFERENCES	32
APPENDICES		33

Shealy Environmental Services, Inc.

Page 3 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

1. PURPOSE

1.1. Sample control procedures are necessary in the laboratory from the time of sample receipt to the time the sample is discarded or returned to the client. Procedures in addition to those outlined in this SOP may be followed or implemented for special projects if and/or when requested by the client.

2. RESPONSIBILITIES

- 2.1 The sample receiving department consists of three full-time designated sample receiving custodians. Several other Shealy employees are cross-trained in this department.
- 2.2 It is the responsibility of the sample receiving custodians, and anyone assisting in the receipt of samples, to adhere to the procedures summarized in this SOP.

3. SAFETY

- 3.1 Procedures shall be carried out in a manner that protects the health and safety of all Shealy personnel. All work must be stopped in the event of a known or potential compromise to the health and safety of a Shealy employee. The situation must be reported immediately to the Environmental Health and Safety Officer (EHSO).
- 3.2 As stated in the *Shealy Comprehensive Chemical Hygiene*, *Safety, and Hazard Communication Plan* (HS SOP ME0012D), eye protection that satisfies ANSI Z87.1, a laboratory coat, and at least latex gloves must be worn while samples, standards, and reagents are being handled. Contaminated disposable gloves are to be removed and discarded.
- 3.3 Be aware of sample container conditions upon inspecting coolers. If broken glass is discovered, cut-proof gloves must be worn while removing contents from the cooler.
- 3.4 The health and safety hazards of many of the chemicals used in these procedures have not been fully defined. Additional health and safety information can be obtained from safety data sheets (SDS) maintained in the public directory. Physical and health hazards specific to this procedure:
 - 3.4.1 The following material(s) are classified as **corrosive**: sulfuric acid, hydrochloric acid, and nitric acid
 - 3.4.2 The following material(s) are classified as **caustic**: sodium hydroxide
 - 3.4.3 The following material(s) are classified as **irritant**: zinc acetate, methanol
 - 3.4.4 The following material(s) are classified as **flammable**: methanol
- 3.5 All reagents must be carefully prepared inside of the fume hood located in the sample receiving area.
- 3.6 When preparing diluted acid, always add acid to water. If the water is added to the acid, a violent reaction may occur.

Shealy Environmental Services, Inc.

Page 4 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

3.7 Samples requiring chemical preservation upon receipt must be carefully preserved inside of the fume hood located in the sample receiving area. If an adverse reaction occurs as a result of preservation attempts, this should be noted on the SRC and the EHSO should be contacted for further guidance.

- 3.8 Employees receiving samples must pay attention to the physical characteristics of the samples being received. Any samples that appear inherently hazardous, or are labeled as containing hazardous substances, must be brought to the attention of the EHSO and the OD prior to sample processing. Indicators of a hazard include, but are not limited to:
 - 3.8.1 A sample is received labeled with a pictogram, fire diamond, or other indication that the sample may pose some hazard;
 - 3.8.2 The chain-of-custody is marked by the client denoting that the samples are hazardous;
 - 3.8.3 Samples are accompanied by a safety data sheet (SDS);
 - 3.8.4 Client sample IDs indicate a potential hazard (example: white phosphorus, asbestos, gasoline spill, etc.);
 - 3.8.5 The sample is bi-phasic (multi-layered).
- 3.9 Samples comprised of commercially available chemical product, or mixtures thereof, must be submitted with an accompanying Safety Data Sheet (SDS) outlining the hazards associated with the materials received. SDSs must be forwarded to the Environmental Health and Safety Officer (EHSO) and Operations Director (OD), immediately upon receipt, for risk evaluation.
- 3.10 Any sample determined to pose a health or physical hazard to employees, must be identified and labeled in a conspicuous manner:
 - 3.10.1 Hazard information must be noted in the comments section of the LIMS5 sample receiving module at the time of sample log-in (example: corrosive, toxic, caustic).
 - 3.10.2 The appropriate hazardous (HAZ) sample container types must be chosen during log-in of samples.
 - 3.10.3 OSHA pictograms, indicating the hazards presented by the sample, must be applied to each applicable sample container. Labels must be applied to the top and side of each bottle (refer to Appendix M for a list of OSHA pictograms and associated hazard classification).
 - 3.10.4 If a SDS is received, each SDS must be scanned into LIMS5. The lot number associated with the samples must be sent to the EHSO.
- 3.11 Shipping containers must be opened in an area providing adequate ventilation to employees:
 - 3.11.1 If container size permits, shipping containers are opened inside of the sample receiving fume hood.

Shealy Environmental Services, Inc.

Page 5 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

3.11.2 If a shipping container is too large to fit inside of the fume hood, it must be opened directly in front of the fume hood. Containers must be placed on the lift jack, no more than approximately 12" from the face of the fume hood sash, and raised such that the lid or opening of the container is approximately half way between the lip of the hood and the certified sash opening. The sash is to be opened at the certified sash height during this process.

3.12 All shipping containers from known radiological sites must be surveyed for radiological contamination, on all external surfaces, prior to sample processing. Radiological screening procedures are outlined in section 4.10. For additional information regarding the safe handling of samples from radiological sites, refer to the *Radiation Safety Plan* [HS SOP ME001I4].

4. PROCEDURE

- 4.1 **Chain of Custody (COC)** Each sample received into the laboratory must be accompanied by a chain of custody. The chain of custody is a legal document which establishes an unbroken, continuous record of the physical possession, storage, and disposal of samples received into the laboratory. The chain of custody must include the following information:
 - Client name
 - Sample ID(s)
 - Date and time of sample collection
 - Sample type (grab or composite)
 - Sample matrix (aqueous, solid, non-aqueous, etc.)
 - Number of containers
 - Sample preservation (H₂SO₄, NaOH, HCl, ice, etc.)
 - Analysis requested
 - Signatures of all persons who held custody of the sample(s) from the time the sample(s) was collected to the time received by the laboratory
 - Signature of the custodian receiving the sample(s) in the laboratory with date and time
 - 4.1.1 Two types of COC records are available for use at Shealy; one for CWA/NPDES sampling events and one for all other sampling events (Appendix A). The CWA/NPDES COC record includes space for the documentation of composite sampling activities (starting and ending date(s) and time(s) for compositing periods).
 - 4.1.2 Chain of custody records are scanned into LIMS5 at the time of sample log-in and are available for viewing by employees who will process the sample(s).
- 4.2 **Internal Chain of Custody** (**ICOC**) Security of samples and sample tracking is accomplished via the LIMS 5 internal chain of custody (ICOC) program. When removing a sample from the sample receiving area, any and all bar code labels attached to each sample container associated with tests must be scanned. The scanning process allows LIMS 5 to keep a record of the person who is taking the sample, the date taken, and the location in the laboratory to which the sample is being taken.
- 4.3 **Sample Receipt Checklist (SRC)** At the time of receipt of any samples into the laboratory, the custodian receiving the samples initiates a Sample Receipt Checklist (SRC; ME0018C; Appendix B).

Shealy Environmental Services, Inc.

Page 6 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

This form is used to assess sample acceptance criteria, to document the condition of the samples being received, and to note any non-conformances (and its resolution, if possible) associated with them.

- 4.3.1 When an anomaly is noted, the sample receiving custodian or the project manager (PM) must resolve the deviation internally and/or notify the client to resolve any discrepancy.
- 4.3.2 Resolutions to any anomalies found during sample receipt must be documented on the SRC to be provided with the final report.
- 4.4 **Sample Storage** Samples must be stored appropriately to maintain preservation, minimize contamination, and ensure sample security within the laboratory.
 - 4.4.1 All samples are stored in clean refrigeration units monitored and maintained between 2.0 and 6.0°C. The temperature of these refrigeration units must be monitored twice daily, except Sundays and holidays with at least a 4 hour interval between the two readings. Sunday and holiday temperatures are read only once. The temperatures of each of the three thermometers (corrected if applicable) are recorded in the "Walk-in Cooler #1 Sample Receiving" log (ME0019L, Appendix K).
 - 4.4.1.1 An NCM must be written if the temperature falls outside of the requirements or if a required temperature is not taken. Add a note to the temperature log that an NCM has been written.
 - 4.4.2 Volatile organic samples are stored separately from all other samples. Volatile samples are stored in separate boxes by test as well. These samples are *ONLY* stored in the volatiles laboratory and do not require transfer from sample receiving via the ICOC (section 4.2).
 - 4.4.3 Sample security is maintained using an internal sample tracking system called the 'ICOC. See section 4.2.
 - 4.4.4 A refrigerated rental trailer will be acquired in case of catastrophic failure of all sample storage units. VOA samples will be segregated from non-VOA sample via the use of air-tight containers within the refrigerated unit.
 - 4.4.5 *CLP Sample Storage* All CLP samples are to be stored in a secure area, accessible only to authorized personnel. CLP samples are not to be tagged with colored dots in order to avoid disposing of the samples early (disposal is not permitted until 100 days have passed).
 - 4.4.5.1 Aqueous CLP samples for Trace VOA analysis and solid samples for VOA testing are stored in their own designated refrigerator in the volatile organic laboratory. Samples for Low-Medium VOA analysis are stored in the VOA walk-in cooler. All other samples for non-VOA analysis are stored in Sample Receiving walk-in cooler.
 - 4.4.5.2 Only Shealy employees that are required for sample receipt and analysis are listed as authorized personnel and have access to locked storage areas.
- 4.5 **Prioritizing Samples** Upon receipt, coolers are prioritized based on holding times and rush requests. Higher priority is assigned to samples with short holding times (12 hours or less remaining) and

Shealy Environmental Services, Inc.

Page 7 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

samples requiring rush turn-around time. CLP samples shall be prioritized according to hold times (24 hours or less (encores) and turn-around-time noted on the COC.

- 4.5.1 If a sample holding time is expiring within 24 hours from the time of receipt, an email must be sent to the appropriate departmental group leader indicating the sample expiration date and time. For samples received on Fridays, Saturdays, and Sundays, the notification extends to any samples expiring within 48 hours.
- 4.5.2 Cooler contents are organized on the sample receiving counter according to the COC.
- 4.5.3 All information on the container labels is verified against the COC and this verification is documented on the SRC. If any of the information is absent or incomplete, the anomaly must be documented on the SRC.
- 4.6 **Secure Area** A secure area is defined as an isolated room or refrigerated space that has restricted access limited to Shealy employees or visitors accompanied by Shealy employees only. The secure areas used are the sample receiving room, sample receiving walk-in cooler and the volatiles walk-in cooler.
 - 4.6.1 In the absence of a sample receiving custodian, the COC is signed and the date, time and temperature of each cooler are recorded. The sample receiving custodian will receive the samples from the secure area upon arrival.
- 4.7 **Sample Acceptance Policy** –This section outlines the necessary information and conditions required for samples to be deemed acceptable upon receipt. All samples received by Shealy must be compliant with the criteria listed on the Sample Receipt Checklist (Appendix B). If all of the criteria are not met, the laboratory will notify the client to determine if they wish to secure another sample, terminate the analysis of the sample, or continue the analysis. If the sample is processed, then a qualifier will be placed on the final report listing the non-conformance(s) or the non-conformance(s) will be documented in the report narrative. A copy of the SRC is included with each report of analysis. All known radioactive samples must be received with screening data and are to be evaluated for acceptance following the procedures outlined in Section 4.10. The sample acceptance policy includes but is not limited to:
 - 4.7.1 All samples submitted must be accompanied by a Chain of Custody (COC). The COC must be completed and contain at a minimum:
 - 4.7.1.1 Unique Sample ID, location of sampling site, date/time of collection, collector's (sampler's) name, preservation type, sample container type, sample type (grab, composite, solid, aqueous, etc.)
 - 4.7.1.2 Any special remarks concerning the sample.
 - 4.7.2 Sample labels must contain unique sample identification and notated using indelible ink. Sample labels must be durable enough to remain intact and on container in wet or cold conditions.

Shealy Environmental Services, Inc.

Page 8 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.7.3 Samples must be submitted in appropriate containers and preservatives according to the analysis being requested. This includes temperature requirements.

- 4.7.4 Samples must be submitted with at least one half of the hold time remaining.
- 4.7.5 Samples must be submitted containing sufficient volume to perform the analysis requested.
- 4.7.6 Samples must be received in unbroken or undamaged containers. Broken or damaged containers can result in contamination of other samples as well as posing a potential health concern to Sample Receiving personnel.
- 4.7.7 Upon receipt by the lab, sample submittals are evaluated on the above mentioned requirements. Any deviation from these requirements will result in the client being contacted by the Project Manager who will inform the client that the data will be qualified if analysis goes forward. The client will then determine if the analysis should go forward.
- 4.7.8 Any sample submittals that are comprised of commercially available products must be accompanied by a Safety Data Sheet outlining the potential hazardous properties.
- 4.7.9 If there are any questions regarding container types, preservatives, hold times or any other aspects of sample requirements based on analysis, the Project Manager should be contacted for guidance.

4.8 **Reagents**

Note: All reagent dilutions are made using reagent water.

Note: Other volumes of standards or reagents may be made to account for expected usage. As long as all ratios are kept constant this is not considered a deviation from this SOP.

Note: All stored reagents are labeled with the following information:

- 1. Name of standard or solution
- 2. Concentration
- 3. **Analyst's Initials**
- 4. **Prep date**
- 5. **Expiration date**
- 6. **Tracking number**
- 7. Warning label of any hazards and/or concentration of acid or base
 - 4.8.1 Reagent water Shealy employs a series of in-house deionized (DI) tanks to purify the incoming water. Reagent water must be free of the analytes of interest as demonstrated through the analysis of method blanks. See the deionized water system SOP (ME0012S) for further information.
 - 4.8.2 Reagent grade chemicals are normally used in sample receiving. Other grades may be used, provided that the reagent is demonstrated to be of sufficiently high purity to permit its use without lessening the accuracy of the determination. Reagents should be stored in glass or Teflon to prevent the leaching of contaminants from plastic containers.

Shealy Environmental Services, Inc.

Page 9 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

- 4.8.3 pH test strips Wide-range, 0-14 SU. Commercially available.
- 4.8.4 Chlorine test strips Commercially available, Hach Cat # 2745050 or equivalent.

NOTE: Other concentrations of NaOH, H₂SO₄, HNO₃ and HCl solutions may be used to adjust sample pH provided that the volume added does not change the total sample volume by more than 1%.

- 4.8.5 Sodium hydroxide solution (10 N), NaOH Purchased from any manufacturer that can provide a certificate of analysis. Note manufacturer expiration date.
 - 4.8.5.1 Alternatively, while stirring, carefully dissolve 200 g of NaOH in approximately 250 mL of reagent water. Allow the solution to cool and dilute to 500 mL. This reagent expires 6 months from the date of preparation.
- 4.8.6 Sulfuric acid solution (1:1), H₂SO₄, Slowly add 250 mL of H₂SO₄ to 250 mL of reagent water. Allow the solution to cool. This reagent expires 6 months from the date of preparation.
- 4.8.7 Nitric acid solution (1:1), HNO₃ Slowly add 250 mL of concentrated HNO₃ to 250 mL of reagent water. Allow the solution to cool. This reagent expires 6 months from the date of preparation.
- 4.8.8 Hydrochloric acid solution (1:1), HCl Slowly add 250 mL of HCl to 250 mL of reagent water. Allow the solution to cool. This reagent expires 6 months from the date of preparation.

4.9 Non-CLP Sample Receipt

Note: Refer to Foreign Soil and Regulated Domestic Soil Sample Receiving, Laboratory Handling, Disposal and Documentation (Policy ME001J9) for special instructions regarding receiving foreign soils.

- 4.9.1 Samples Received via Fed Ex, UPS, or Other Commercial Courier
 - 4.9.1.1 Examine the shipping container for damage and to ensure the integrity of the container has not been compromised.
 - 4.9.1.2 Inspect the shipping container for the presence of custody seals. Note the presence or absence of custody seals on the SRC. If custody seals are present, note their condition on the SRC.
 - 4.9.1.3 Containers that are not securely fastened with tape, or other form of closure, should be noted on the SRC.
 - 4.9.1.4 Open the shipping container under adequate ventilation as described in section 3.11. The container must be opened in this manner to reduce employee exposure to hazardous fumes resulting from potentially broken sample containers.

Shealy Environmental Services, Inc.

Page 10 of 59
Document Number: ME0013H-08

Effective Date: 5/8/2018

4.9.1.5 Locate the COC associated with the shipment and remove the courier shipping labels. The shipping labels are maintained along with the COC and SRC. If the label cannot be salvaged, the package tracking # is written on the SRC.

- 4.9.1.6 *Immediately* determine the receipt temperature before the shipping container is unpacked so that samples only stand at room temperature for a minimal amount of time. Receipt temperatures must be determined for each individual shipping container.
 - 4.9.1.6.1 The temperature is determined using an infrared (IR) thermometer, or equivalent. The infrared thermometer should be aimed at the sample container label in order to avoid interference from ice or condensation.
 - 4.9.1.6.2 If a temperature blank is provided inside of the shipping container, it *must* be used for temperature determination; otherwise, a *single* representative sample container should be used. The method of determination must be noted on the SRC.
 - 4.9.1.6.3 If a correction factor has been assigned to the IR thermometer, it must be added to or subtracted from the apparent reading every time a temperature is determined. The unadjusted temperature reading, adjusted temperature reading, IR thermometer ID, and correction factor must be noted on the SRC.
 - 4.9.1.6.4 The adjusted temperature reading must be documented on the COC. Additionally, the presence or absence of ice and a temperature blank must be noted on the COC. The "Lab Use Only" section of the COC is designated for the documentation of this information. Information must be documented on each page of the CoC.
- 4.9.1.7 Adjusted temperature readings must be transferred into LIMS5 at the time of sample log-in. This information is recorded in the "edit coolers" window which appears onscreen during the lot creation process. The adjusted temperature must be recorded for each shipping container received. If a receipt temperature is greater than 6°C, LIMS will automatically notify the PM via email.
- 4.9.1.8 When samples are received via a commercial courier, both the "relinquished by" and "laboratory received by" portions of the COC must be completed by the employee receiving the samples. The "relinquished by" space should reflect the method of delivery (FedEx, UPS, etc.) The relinquish date and time must be indicative of when the shipment was received. The employee receiving the samples must legibly sign the "laboratory received by" portion of the COC. The laboratory receipt date and time must exactly match the relinquish date and time. **NOTE: Initials are not an acceptable signature.**
- 4.9.2 Samples Received Directly From The Client

Shealy Environmental Services, Inc.

Page 11 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.9.2.1 When samples are received directly from a client, the COC must be signed as relinquished by the client and signed as received by the laboratory. The relinquish date and time must reflect the date and time in which the samples are being dropped off. The laboratory receipt date and time must exactly match the relinquish date and time. The client is provided a copy of the CoC.

Note: Any Shealy employee may receive samples from a client. Sample receiving summary procedures are posted in the sample receiving area and are included in Appendix F of this procedure.

- 4.9.2.2 Open the shipping container under adequate ventilation as described in section 3.11. The container must be opened in this manner to reduce employee exposure to hazardous fumes resulting from potentially broken sample containers.
- 4.9.2.3 *Immediately* determine the receipt temperature as per sections 4.9.1.6.1 through 4.9.1.6.4 before the shipping container is unpacked so that samples only stand at room temperature for a minimal amount of time. Receipt temperatures must be determined for each individual shipping container.
- 4.9.3 Coolers Delivered by Shealy Field Services (FS)
 - 4.9.3.1 When samples are delivered by field personnel and a sample receiving custodian is present, the COC must be signed as relinquished by the field technician and signed as received by the sample receiving custodian. The relinquish date and time must reflect the date and time in which the samples are being dropped off. The laboratory receipt date and time must exactly match the relinquish date and time.
 - 4.9.3.2 When samples are delivered by field personnel and a sample receiving custodian is not present, but it is during normal business hours, the COC must be signed as relinquished by the field technician and signed as received by "SESI secure area". The relinquish date and time must reflect the date and time in which the samples are being dropped off. The received by date and time must exactly match the relinquish date and time. Both the "relinquished by" and "received by" portions of the COC must be completed by the field technician.
 - 4.9.3.3 The field technician must immediately determine the receipt temperature of each individual shipping container as per sections 4.9.1.6.1 through 4.9.1.6.4.
 - 4.9.3.4 If sufficient ice is present to keep the cooler at ≤ 6°C until the cooler is inspected and unpacked by a sample receiving custodian (no longer than overnight), the cooler(s) may be left in the middle of the sample receiving area. The COC must be left in a conspicuous manner.
 - 4.9.3.5 If there is insufficient ice to maintain a temperature of ≤6°C, the cooler must be placed in the sample receiving walk-in cooler unless volatile samples are present in the cooler. VOLATILE SAMPLES CANNOT BE STORED IN THE SAMPLE RECEIVING WALK IN COOLER. Volatile samples must be placed in the walk-in cooler located in the volatiles department or the cooler should

Shealy Environmental Services, Inc. Document Number: ME0013H-08

remain in the sample receiving secure area after enough ice is added to the cooler to maintain a temperature of \leq 6°C. The COC must be placed on the counter in sample receiving with instructions as to where the samples are stored.

- 4.9.4 Samples Received by Lab Personnel Outside Normal Business Hours
 - 4.9.4.1 Outside of normal business hours, on weekends, and/or on holidays samples may be received by lab personnel in the absence of a sample receiving custodian. The COC must be signed as relinquished by a field technician, commercial courier (refer to section 4.9.1), or a client (refer to section 4.9.2) and signed as received by the employee receiving the samples. The relinquish date and time must reflect the date and time in which the samples are being dropped off. The received by date and time must exactly match the relinquish date and time.
 - 4.9.4.2 *The employee must immediately* determine the receipt temperature of each individual shipping container. The temperature is determined using an infrared (IR) thermometer as per sections 4.9.1.6.1 through 4.9.1.6.4.
 - 4.9.4.3 If sufficient ice is present to keep the cooler at \leq 6°C until the cooler is inspected and unpacked by a sample receiving custodian (no longer than overnight), the cooler(s) may be left in the middle of the sample receiving area. The COC must be left in the sample receiving area in a conspicuous manner.
 - 4.9.4.4 If there is insufficient ice to maintain a temperature of $\leq 6^{\circ}$ C, the cooler must be placed in the sample receiving walk-in cooler unless volatile samples are present in the cooler. VOLATILE SAMPLES CANNOT BE STORED IN THE SAMPLE RECEIVING WALK IN COOLER. Volatile samples must be placed in the walk-in cooler located in the volatiles department or the cooler should remain in the sample receiving secure area after enough ice is added to the cooler to maintain a temperature of $\leq 6^{\circ}$ C. The COC must be placed on the counter in sample receiving with instructions as to where the samples are stored.
- 4.9.5 Using the SRC to Assess Sample Acceptance Criteria, Document Sample Condition, and Communicate Non-Conformances
 - 4.9.5.1 The SRC is a form used to assess sample acceptance criteria, to document the condition of the samples being received, and to note any non-conformances (and its resolution if possible) associated with them.
 - 4.9.5.2 SRC records are scanned into LIMS5 at the time of sample log-in and are available for viewing by employees who will process the sample(s). If a sample condition warrants attention by laboratory personnel, the receiving employee must place a "SEE SRC" label on each applicable sample bottle to prompt the laboratory to reference the SRC for information.
 - 4.9.5.3 The following sample conditions are checked and recorded on the SRC:

Shealy Environmental Services, Inc.

Page 13 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.9.5.3.1 The presence or absence of custody seals. If custody seals are present, note their condition on the SRC. If custody seals are absent, note this on the SRC.

- 4.9.5.3.2 Sample receipt temperatures The unadjusted temperature reading and adjusted temperature reading of the sample shipping container(s). The method of determination (temperature blank or against bottle) is also noted on the SRC.
- 4.9.5.3.3 Receipt of samples collected in containers appropriate for the analysis requested. Sample containers are also observed for condition (unbroken, lids intact, etc.).
- 4.9.5.3.4 Adequate sample volume for the analysis requested. **Note: Contact PM** immediately if inadequate sample volume is received.
- 4.9.5.3.5 Adequate hold time remaining for analysis samples received within ½ the holding time.
- 4.9.5.3.6 Bubbles present in VOA/RSK-175 vials (compare to a 6 mm comparison device available in the sample receiving area).
- 4.9.5.3.7 Appropriate chemical preservation for the analysis requested (unless it is not technically acceptable to check preservation upon receipt (e.g. VOA vials, microbiology samples)).
- 4.9.5.3.8 Absence of chlorine where applicable (when NH₃, TKN, Cyanide, Phenol, and/or BNA analysis is requested).
- 4.9.5.4 Additional quality elements reviewed and recorded on the SRC:
 - 4.9.5.4.1 Receipt and maintenance of a courier packing slip (where applicable).
 - 4.9.5.4.2 Proper custody procedures followed (samples properly relinquished by and received by each party involved).
 - 4.9.5.4.3 The contents of each cooler is checked against the COC.
 - NOTE: If information on the bottles conflicts with the information on the COC, then the information on the COC takes precedence. All discrepancies must be noted on the SRC.
 - 4.9.5.4.3.1 Sample IDs
 - 4.9.5.4.3.2 Collection date and time (if collection date/time is not found on the COC, this information may be found on the bottles; document this on the SRC)

Shealy Environmental Services, Inc.

Page 14 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

NOTE: If the sample is a short hold and the date/time is earlier on the bottle than on the COC, the PM must be notified immediately.

- 4.9.5.4.3.3 Tests to be performed (if tests are not listed on the COC, then log the samples for the tests as per the bottle label and note this on the SRC).
- 4.9.5.4.3.4 Missing or extra samples (Any extra sample containers received or any missing samples as compared to the COC should be noted on the SRC. Contact the PM for further instructions.)
- 4.9.5.4.4 Assurance that client requests such as turnaround time, dilutions, analysis hold and separate reports are transcribed from the COC to the comments in LIMS 5.
- 4.9.5.4.5 Presence of a quote number on sample container(s).
- 4.9.5.4.6 The client may request a special dilution or other treatment for microbiology samples in which case the information should be transcribed as above and the bottle labeled accordingly (for example: write "Dilute" on the bottle cap or label). For storm water microbiology samples, "Storm water" must be entered into the comments in LIMS and the letters "SW" are written on the bottle cap or label. These samples will require a special dilution.
- 4.9.6 Thermal Preservation of Samples
 - 4.9.6.1 If the samples being received into the laboratory require thermal preservation, the temperature of the sample must be determined and documented upon arrival (EQI Analytical Methods list [Administrative Form ME002BS] contains the thermal preservation required for each of the tests performed at Shealy).
 - 4.9.6.2 Samples that require thermal preservation must arrive at a temperature of less than or equal to 6° C.
 - 4.9.6.2.1 Samples that are hand delivered to the laboratory immediately after collection may not meet these criteria. In these cases, the samples shall be considered acceptable if there is evidence that the chilling process has begun, such as arrival on ice.
 - 4.9.6.2.2 The sample custodian must notify the project manager *immediately* either by phone, email or face-to face if the temperature is greater than 6 ° C. The PM will contact the client.

Shealy Environmental Services, Inc.
Document Number: ME0013H-08

Page 15 of 59 Effective Date: 5/8/2018

NOTE: LIMS 5 will automatically send an email to the PM when thermal preservation requirements are not met.

- 4.9.7 Chemical Preservation of Samples
 - 4.9.7.1 In addition to thermal preservation, chemical preservation is also required for some analyses. Chemical preservation must be checked at the time of sample receipt for all samples requiring chemical preservation, unless it is not technically acceptable to do so (e.g. Oil and Grease, VOA, and microbiology samples). Additionally, if a sample is received with documented information indicating that improper preservation has been used (sample bottle labels denote improper preservation for the tests being requested), the preservation must be checked. **Refer to the EQI Analytical Methods list [Administrative Form ME002BS] for a list of the types of chemical preservation required for each test.**
 - 4.9.7.2 In order to ensure that cross-contamination does not occur, an aliquot of sample is removed from the sample container and that aliquot is used to determine either the pH or chlorine content (TRC) of the sample. **Test strips must not be dipped directly into sample containers.**
 - 4.9.7.2.1 pH paper is used to verify proper pH preservation of samples. Samples requiring acidic conditions are verified in the 0-6 SU range. Samples requiring basic conditions are verified with 7 to 14 SU range.
 - 4.9.7.2.2 Chlorine test strips are used to detect the presence of chlorine. The strips are capable of a detection range of 0 10 mg/L of free and total chlorine.
 - 4.9.7.3 During preservation verifications, care must be taken to ensure sample run-off is not allowed to spill from test strips onto the benchtop. Sample runoff must be collected in a waste container and managed as required by Shealy's *Hazardous and Non-Hazardous Waste Management Plan* (ME0012A).
 - 4.9.7.4 If a sample requires adjustment to meet chemical preservation requirements, the need for preservation adjustment and the chemical ID(s) associated with the chemicals used must be documented on the SRC. Additionally, the ID(s) of the test strips used during preservation verifications and the time of sample preservation must be documented on the SRC.
 - 4.9.7.5 If a sample is unable to be preserved, the receiving employee must note this on the SRC and perform the following actions:
 - 4.9.7.5.1 Document "See SRC" in the comments section of LIMS5 followed by the applicable department. Example: "See SRC (IM)".
 - 4.9.7.5.2 Place a "SEE SRC" label on the applicable sample bottles.
 - 4.9.7.5.3 Send an email to the applicable department group leader.

Shealy Environmental Services, Inc.

Page 16 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.9.7.6 The following chemical preservations must be checked upon sample receipt:

- 4.9.7.6.1 A pH of <2 SU is required for all DRO, metals and nutrient samples.
 - 4.9.7.6.1.1 Samples submitted for metals analysis that require preservation at the time of receipt will be noted in the comments section of the Sample Receiving module in LIMS 5 as "preserved at 'time' on 'date'". This comment will appear on the Metals Prep widget (see "Note" below).
 - NOTE: For samples to be analyzed by methods 200.7, 200.8 or 245.1 and collected the day of receipt, a 16 hour (drinking water) or 24 hour (non-potable water) waiting period is required after preservation. These samples are preserved by sample receiving and held in the sample receiving walk-in cooler. After the waiting period has expired, the samples are transferred to the metals department where the samples are tested for pH again. If the pH is >2, the samples are further preserved and held again in the metals department for the required waiting period listed above. This procedure will be followed until the pH is <2.
 - 4.9.7.6.1.2 A pH of >12 SU is required for cyanide samples and a pH >9 SU is required for sulfide samples.
 - 4.9.7.6.1.3 SC DHEC drinking water project samples require a pH of <2 SU.
 - 4.9.7.6.1.4 Analyses including ammonia, TKN, cyanide, phenol, and BNA (625.1), (from chlorinated sources such as drinking water), must be verified to ensure that they are free of residual chlorine (< 0.5 mg/L).
 - 4.9.7.6.1.5 If residual chlorine is present at > 0.5 mg/L in samples to be analyzed for cyanide, notify the Inorganic Non-Metals group leader immediately. An INM analyst will treat the samples for chlorine according to the appropriate cyanide analysis SOP.
 - 4.9.7.6.1.6 For all other samples, if > 0.5 mg/L of chlorine is present, the sample is de-chlorinated with sodium thiosulfate. Add a small amount of sodium thiosulfate to the sample, mix well and test the chlorine again. Continue until the chlorine is < 0.5 mg/L.
- NOTE: Sample preservation adjustments must be performed inside of the fume hood located in the sample receiving area.
- NOTE: If a sample requires pH adjustment, care must be taken to ensure that the volume of acid or base added does not change the total sample volume by

Shealy Environmental Services, Inc.

Page 17 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

more than 1 %. [For 250 mL sample volumes, no more than 2.5 mL of acid or base may be used for adjustment. For 500 mL sample volumes, no more than 5 mL of acid or base may be used for adjustment. For 1000 mL sample volumes, no more than 10 mL of acid or base may be used for adjustment.]

4.9.8 *Other Preservation*

4.9.8.1 Dissolved Metals

- 4.9.8.1.1 For dissolved metals analysis, the sample must arrive in the appropriately preserved or non-preserved container according to whether filtration occurs in the field or in the lab.
- 4.9.8.1.2 For a field filtered dissolved metals sample, the container should be received preserved with nitric acid and the HNO3 (dissolved) container will be selected in LIMS 5. "Field filtered" must be entered into the comments section of LIMS 5.
- 4.9.8.1.3 For a dissolved metals sample to be filtered in the lab, the container must be unpreserved (dissolved). The sample receiving custodian must log in the unpreserved container and a nitric bottle to be used when prepping the sample into LIMS 5. "Lab to filter" must be entered into the comments section of LIMS 5.
- **NOTE:** If a sample container is to be logged for dissolved metals, but the sample is unpreserved and the client indicates that the sample has not been filtered in the field, then the sample should not be preserved. Leave the sample as is.

4.9.8.2 Orthophosphate Samples

- 4.9.8.2.1 Field Services must filter orthophosphate samples in the field and subsequently indicate on the chain of custody that the orthophosphate sample was field filtered. Sample receiving custodians must enter "field filtered" in the comments section of LIMS 5.
- 4.9.8.2.2 At times, orthophosphate samples may be received that have not been field filtered (client delivered or shipped samples). In this case, Sample Receiving custodians must enter "needs filtered" in the comments in the sample receiving module in LIMS 5 when the sample has not been field filtered.

4.9.9 Client Requested Information and Special Sample Handling

4.9.9.1 At times, clients may document requests for special treatment and/or handling of samples in the comments section of the associated chain of custody. When this occurs, the receiving employee should perform the following actions:

Shealy Environmental Services, Inc.

Page 18 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.9.9.1.1 Document "See CoC" in the comments section of LIMS5 followed by the applicable department. Example: "See CoC (EXT)".

- 4.9.9.1.2 Place a "SEE CoC" label on the applicable sample bottles.
- 4.9.9.1.3 Send an email to the applicable department group leader.
- 4.9.10 Storm Water Samples for Microbiological Analysis
 - 4.9.10.1 Storm water samples submitted for microbiological analysis require dilution during preparation procedures. If a sample container or chain of custody denotes that a sample is comprised of storm water, the receiving employee must place an "SW" label on the applicable bottle and put "stormwater" in the comments section of LIMS5.
- 4.9.11 *Inspection of Volatile Samples* All aqueous volatile samples received in the laboratory must be inspected to verify the presence of air bubbles or headspace. If a sample vial is found to contain an air bubble greater than "pea-sized" (1/4 inch or 6 mm diameter), document the sample number and number of vials affected on the SRC.
 - 4.9.11.1 Trip blanks may be received with volatile samples. Sometimes multiple trip blanks are received from several coolers, but are not labeled uniquely. The custodian will isolate the trip blanks from each cooler and log them in separately, so that one trip blank is received for each cooler that contains volatile samples. If the ID of each set of the trip blanks is not unique, contact the PM for resolution.
 - 4.9.11.2 Several trip blanks may be received in one cooler in which case, consolidate the vials into one sample ID. If trip blanks are received without volatiles, then document this on the SRC.
 - 4.9.11.3 In LIMS 5, trip blanks must be associated with the cooler they were received in. Also, the associated samples for each trip blank set need to have the cooler temperature and cooler number noted in LIMS 5.
 - 4.9.11.4 At times, volatile samples may need to be prepared from samples submitted for testing which arrive in bulk (not in VOA vials). These samples may be poured up in the volatiles lab fume hood or in the sample receiving fume hood.
- 4.9.12 Sample Containers EQI Analytical Methods list [Administrative Form ME002BS] contains a listing of each method that Shealy performs along with pertinent information such as sample volume, sample containers, holding times, and preservatives. During sample receipt, this information must be confirmed to ensure that all of the method specific requirements are met before analysis can begin.
 - 4.9.12.1 If a sample is received in an incorrect container, note this on the SRC and transfer the sample to the correct container.

Shealy Environmental Services, Inc.

Page 19 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.9.12.2 If a sample container is provided by the client and does not conform to the preservation requirements, the custodian will adjust the pH and record incorrect preservation and adjustments made on the SRC. This is usually done when only one analysis is needed.

- 4.9.12.3 If multiple analyses requiring different preservatives are requested, the custodian will aliquot the sample into the appropriate containers needed for each analysis from the original after shaking the original container well for 5 seconds.
 - 4.9.12.3.1 If the sample is to remain in the client's original container, the "client provided" container must be selected with the appropriate preservative in LIMS.
 - 4.9.12.3.2 If the sample is transferred to the appropriately-preserved container(s) from the client's original, the final container(s) will be selected in LIMS.
- 4.9.12.4 For any dissolved analysis, the appropriately sized container labeled "dissolved" in LIMS 5 must be selected. This ensures that the analyst is taking the sample from the proper container.
- 4.9.12.5 Soil samples may be collected in Encore samplers. When such soil samples are received by the laboratory, the encore container will be selected in LIMS 5 and an extra label is printed for each Encore sampler received. These samples must be prepared and preserved within 48 hours of collection; therefore the *volatiles lab will require prompt notification* when any Encore samplers are received. If no one is working in the volatiles lab, then use the volatiles department phone list in order to ensure that a volatiles employee is informed that encore samples have been received. This must be accomplished prior to leaving for the day.
- 4.9.12.6 If volatiles analysis of soils has been requested and there is no separate sample (soil kit) appointed for this, then transfer some of the soil sample to a 2 oz jar. This sample should be placed in the appropriate volatiles department refrigerator and the volatiles lab should be notified.
- 4.9.12.7 Any non-conformance (and its resolution if possible) should be documented on the SRC.
- 4.9.13 *Sub-sampling* If samples must be split because the client sent an insufficient number of containers for the required analysis, the following procedures apply:
 - 4.9.13.1 Aqueous samples Shake the parent sample vigorously for at least 5 seconds or more based upon the sample homogeneity. Quickly and carefully pour a portion of the sample into the proper container and preserve appropriately. Document this on the SRC.
 - **NOTE:** Refer to the QAMP for the minimum volume required for analysis. Contact the PM to determine which tests should be poured up if there is not enough

Shealy Environmental Services, Inc.

Page 20 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

sample for all of the tests requested. Some analyses may be run from the same sample volume, but this option should be discussed with the PM and the department group leader.

- 4.9.13.2 Non-aqueous liquid samples Pour single phase liquid into appropriate container. If sample has multiple phases, notify the PM for instructions on how to proceed. If phase separation is required, notify the Operations Director or Extractions Group Leader. The sample should be separated using an appropriate sized separatory funnel. The phases should be labeled (i.e. top layer, bottom layer, black layer, etc.), placed into the appropriate container and entered into the LIMS system using appropriate description. Document the phase separation on the SRC.
- 4.9.13.3 Solid samples See section 4.12.
- 4.9.13.4 If the sample matrix is ambiguous and no matrix has been indicated on the COC, then the sample matrix must be tested. When discerning between aqueous and non-aqueous, a 50 mL digestion tube is filled with water and an aliquot of the sample is added to the water. Observe as to whether the sample mixes with the water or remains completely separate. The results must be reported to the PM who will assist in designating a matrix. If discerning between non-aqueous/aqueous and solid then the PM and the extractions department must be enlisted to test the matrix and a decision made accordingly.
- 4.9.14 *Handling of Solid Samples* At times, solid samples may need to be transferred to other sample containers.
 - 4.9.14.1 Free-flowing homogeneous samples such as sand can be transferred to other sample containers using a tongue depressor or by pouring directly into the appropriate containers.
 - 4.9.14.2 Non-free-flowing samples and/or non-homogeneous samples such as clay, sediment, etc. are transferred to a larger container such as a one-liter wide mouth glass container and shaken or mixed and then transferred into appropriate containers.
 - 4.9.14.3 Percent Solids Determination All soil and sediment samples are subsampled from the largest parent sample container provided into a 0.5 oz snap-seal plastic container for percent solids determination.
 - 4.9.14.3.1 Initial weight of snap seal container Tare the weigh boat on the balance. Then place the % solid label on the weigh boat. Begin weighing each empty snap seal container by placing each one on the weigh boat and recording the weight on the bottom of each snap seal container.
 - 4.9.14.3.2 To fill a snap seal container with sample for % solids determination: Using a tongue depressor, core a representative sample aliquot from the decanted sample container and transfer 5 to 10 g of sample into the

Shealy Environmental Services, Inc.

Page 21 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

snap-seal plastic container. In the event that there is not enough sample available, use the sample in the volatiles (VOA) screening vial to make a % solid sample. Document that the screening vial was used for % solids. At times a sample is such that a % solid sample cannot be made. When this occurs, document on the SRC that a % solid sample could not be made due to matrix.

- 4.9.14.4 Percent Moisture Determination If standing water is observed in a parent sample container, the PM should be contacted prior to sub-sampling for % moisture. The standing water may need to be poured off.
- 4.9.15 *Compositing Samples* Some samples are to be composited after they are received by the laboratory.
 - 4.9.15.1 Aqueous samples must be shaken vigorously for at least 5 seconds. The volume required from each sample is poured into a clean, glass container and mixed thoroughly.
 - 4.9.15.1.1 The resultant composite sample is then poured into the appropriate containers for the analyses requested.
 - 4.9.15.2 Solid samples are transferred to a larger container, such as a one-liter wide mouth glass container, and shaken or mixed and then transferred into appropriate containers.
 - 4.9.15.3 The date and time that the sample was composited, along with the initials of the compositor will be documented on the SRC.
 - 4.9.15.4 The samples used to make the composite sample are entered into LIMS 5 (as LOT#-001, LOT#-002, LOT#-003...) These samples will not be logged in for any tests, and a comment is added in the comments section identifying them as composite components. Then the composite sample is entered as a separate sample in the same lot with the tests required.
- 4.9.16 Entering COC information into LIMS 5

NOTE: See the LIMS User Guide SOP (ME001IS) for instructions on using the LIMS system.

- 4.9.16.1.1 LIMS 5 is used for project management, scheduling, and for the internal tracking of samples from receipt, through analysis and to final disposal.
- 4.9.16.1.2 All information on the COC is entered, including the COC number, project name and numbers and PO numbers when applicable.
- 4.9.16.1.3 Samples are assigned a lot number and a barcode label is printed for each sample container. The lot number provides receipt and login information for each sample that is received into the laboratory.

Shealy Environmental Services, Inc.

Page 22 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.9.16.1.3.1 The lot number allows each sample to have unique sample identification (Example: QB27030-001)

- 4.9.16.1.3.1.1 The first letter of the lot number corresponds to the current year (i.e., P=2014, Q=2015, R=2016, etc.)
- 4.9.16.1.3.1.2 The second letter corresponds to the current month (i.e., A=January, B=February, C=March, etc.)
- 4.9.16.1.3.1.3 The first two numbers correspond to the day of the month.
- 4.9.16.1.3.1.4 The two numbers before the dash indicate the lot numbers received that day, in chronological order, as delivery groups of samples are received.
- 4.9.16.1.3.1.5 The last three numbers, which are preceded by a dash, reflect the total number of samples included in that lot. For example, JK06001-003 was in the first lot of samples received November 6, 2008 and is the third sample in that lot.
- 4.9.16.1.3.1.6 The labels also contain a unique bottle identifier that consists of (4) letters and (2) numeric values that change sequentially per container so that no containers have the same ID and can be tracked by the LIMS system to identify the location of each individual container.
- 4.9.16.1.4 The laboratory generated bar code labels are applied to the sample containers in sample receiving.
- 4.9.16.1.5 Further assessment is made concerning holding times, as it is imperative that samples are analyzed within the stipulated maximum holding time.
 - 4.9.16.1.5.1 Shealy is responsible for meeting all holding times for properly preserved samples received within 48 hours of collection, or within one half the holding time, whichever is shortest.
 - 4.9.16.1.5.2 Samples with short holding time left prior to expiration, such as those for BOD, fecal coliform, hexavalent chromium, etc., require immediate notification of the laboratory to ensure analysis within the holding time.
- 4.9.17 Sample Receiving Review A final review by the sample receiving custodian is required after the samples have been entered into LIMS 5 and before proceeding to the next lot. The

Shealy Environmental Services, Inc.

Page 23 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

custodian will perform a cursory on-screen level I review of the lot and promote from "Lot Creation" to "Sample Receiving Review". A level 1 review of the lot includes:

- 4.9.17.1 Ensuring that all information from the COC has been entered into LIMS correctly and completely.
- 4.9.17.2 Ensuring that the SRC has been filled out completely and appropriately.
- **NOTE:** Once a cooler has been emptied, remove all labels and packing materials (bubble wrap, etc.) from the outside of the cooler which were applied during prior usage of the cooler. It is especially important to remove any radiation safety labels prior to the next usage.
- 4.9.18 Sample Receiving Communication Form During the login process, questions or concerns must be addressed verbally with the PM. When PMs are not available, notification of any questions or concerns are communicated via the "Sample Receiving Communication" yellow notification form (ME001US, Appendix G). These forms are not to be used as a substitute for verbal communication during business hours. Any questions or concerns about rush or short holds must be verbally communicated to the PM immediately. The communication form must not be used for rush or short holds.
 - 4.9.18.1 The communication form should be used at a minimum for questions or concerns that are not detrimental to the performance of the lab and will not hinder any analytical processes from occurring. This form is not used for non-conformances. Non-conformances (and its resolution if possible) must be documented on the Sample Receipt Checklist.
 - 4.9.18.2 The Sample Receiving Communication form is attached to the chain of custody.

4.10 Radioactive Sample Handling: DOE / Savannah River Site (SRNS) H-16 Special Handling

- 4.10.1 Based on screening done by SRNS at the H-16 site on samples intended for analysis at SES, notification is sent to the lab confirming that the tritium concentration in those samples is less than or equal to 20 micro curies/L. If this level is exceeded then the samples will not be sent to the lab and if they are inadvertently sent, they are to be *immediately* returned. All H-16 site samples are ultimately returned after analysis regardless of tritium levels.
- 4.10.2 In accordance with South Carolina Department of Health and Environmental Control (SCDHEC) Radioactive Materials License No 426, Shealy must perform surveys of <u>all</u> incoming samples authorized by the license.
 - 4.10.2.1 Any sample measuring at or above 20 counts per minute (CPM) must be immediately returned to the original sender *without* being opened or processed. Samples must be segregated, in a designated location (beside the fume hood in SR), and held for pick-up by the sender.
- 4.10.3 When a shipping container is determined to contain samples requiring survey, the shipping container and samples may not be processed until the following procedure is complete and

Shealy Environmental Services, Inc.

Page 24 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

recorded using the Radioactive Materials Survey Log (ME001O3; Appendix L). Once completed, save the survey log on the public drive (P:\Health and Safety\Radioactive Materials Receipt).

- 4.10.3.1 This procedure fulfills the requirements of Section RHA 3.26 of the State of South Carolina's Regulation 61-63 concerning radioactive materials.
- 4.10.3.2 The procedure should be followed as soon as possible after receipt but no more than 3 hours once the shipping container is received at the facility during normal business hours, or no more than three hours from the beginning of the next working day if received after working hours.
- 4.10.3.3 See Appendix J for details regarding the use of surveying equipment.
- 4.10.3.4 Before the shipping package is opened, all documentation such as the COC and shipping papers are reviewed to ensure the shipment is proper. Acknowledgement of complete documentation is noted on the attached Radioactive Materials Survey Log (RMSL).
- 4.10.3.5 The exterior of the shipping container is examined for integrity and signs of physical leakage. The condition is noted on the RMSL.
- 4.10.3.6 **Background** A sterile survey wipe is placed on a flat surface and surveyed for background radiation using two different survey meters as listed below. The results are recorded on the RMSL.
 - Survey A Beta and Gamma Meter - Eberline Model E-120E Geiger Counter
 - Survey B Alpha and Low energy Beta (Tritium) Meter - Ludlum Model 44-110 Gas Flow Proportional Tritium Detector
- 4.10.3.7 **Exterior** The exterior of the package is surveyed for radiation "leakage" per 10 CFR 71.47 and "removable" radiation per 10 CFR 71.87 (i) with two different survey meters as listed below. All external surfaces of the package must be wiped with a survey wipe and read with both meters. The results are recorded on the RMSL.
 - Survey A Beta and Gamma Radiation Meter - Eberline Model E-120E Geiger Counter Limit ± 20 CPM (plus background CPM)
 - Survey B Alpha and low energy Beta (Tritium) Radiation Meter - Ludlum Model 44-110 Gas Flow Proportional Tritium Detector Limit - 20 CPM (plus background CPM)

Shealy Environmental Services, Inc.

Page 25 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.10.3.8 If removable radiation readings are less than 20 CPM, the shipping package is opened in the following manner and the integrity of the sample containers is visually checked and noted on the RMSL.

- 4.10.3.9 If the shipping container size permits, shipping containers will be opened inside of the sample receiving hood. If a shipping container is too large to fit inside of the fume hood it must be opened directly in front of the fume hood. Shipping containers must be placed on the lift jack, no more than approximately 12" from the face of the fume hood sash, and raised such that the lid of the shipping container is approximately half way between the lip of the hood and the certified sash opening. This sash is to be opened at the certified sash height during this process.
- 4.10.3.10 **Interior** The interior of the package is then surveyed for "removable" radiation (as was the exterior in 4.13.3.7 above). All internal surfaces of the shipping container, including sample containers, are wiped with a survey wipe and the wipe is read with both meters. The results are recorded on the RMSL.
 - Survey A Beta and Gamma Radiation Meter - Eberline Model E-120E Geiger Counter Limit ± 20 CPM (plus background CPM)
 - Survey B Alpha and low energy Beta (Tritium) Radiation Meter - Ludlum Model 44-110 Gas Flow Proportional Tritium Detector Limit - 20 CPM (plus background CPM)
- 4.10.4 If all readings (steps 4.13.3.7, and 4.13.3.10) are within limits, the samples are accepted and may be removed from the shipping container and received via the procedures above.
 - **NOTE**: All sample containers must be logged into LIMS 5 using the "RAD" bottle type.
- 4.10.5 If any of the meter readings from either step 4.13.3.7 or step 4.13.3.10 exceeds the limits, or other abnormalities are detected such as a damaged shipping container, the Laboratory Director and the Radiation Safety Officer must be summoned immediately. The Radiation Safety Officer must report the exceedance to the DHEC Bureau of Radiological Health in an expeditious manner. The shipping container and its contents will be properly secured and isolated awaiting disposition.
- 4.10.6 See section 4.12 for return of radioactive samples.
 - **NOTE:** Once a cooler or reusable shipping container has been emptied, remove all labels from the outside of the cooler which were applied during prior usage of the cooler. It is especially important to remove any radiation safety labels prior to the next usage.
- 4.11 **Subcontracted Sample Transfer -** Shealy does not subcontract analytical analysis without prior notification to the client. When samples are subcontracted, a new COC is issued to the subcontract laboratory with all pertinent information and a carbon copy is kept for tracking purposes. Shealy

Shealy Environmental Services, Inc.

Page 26 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

retains the original COC and includes the new subcontracted COC with the project file. The samples should be scanned out as "Subcontracted" in the ICOC system prior to shipping.

- 4.11.1 Prior to sub-contracting any analyses, Shealy will confirm that the laboratory being considered to receive samples is fully qualified and certified by the regulatory agency necessary to conduct the analyses on those samples. See the procurement SOP (ME0015U) for further information.
- 4.11.2 A sample that is being subcontracted should be placed in a cooler with sufficient ice to maintain the proper thermal preservation.
 - 4.11.2.1 Ice should be double-bagged to prevent leakage and placed on the bottom and sides of the cooler, at a minimum.
 - 4.11.2.2 A temperature blank must be added to each cooler and should be in direct contact with the ice.
 - 4.11.2.3 The sample should be well protected by packing the cooler with enough packing material to ensure that the sample will not shift during shipment. This is to protect the sample from breakage.
 - 4.11.2.4 Place the COC in a plastic bag and place inside the cooler.
 - 4.1.1.1 Place custody seals on the cooler.
 - 4.11.2.5 Tape the cooler with a sufficient amount of packing tape to ensure that the cooler will not open during shipment.
 - 4.11.2.6 Place the appropriate shipping label on the outside of the cooler and leave the cooler in the designated courier pickup area (FedEx Express is picked up from the front of the building outside the lobby, FedEx Ground / UPS is picked up from outside the SR doors at the side of the building)

NOTE: If the sample(s) to be subcontracted are hazardous, then contact the EHSO concerning the proper shipping placarding.

- 4.11.3 When samples are received that require a subcontracted analysis, the test is logged in with the appropriate subcontract test and a notification is sent to the PM via email. The PM fills out a Subcontract Shipping Record Form (Refer to Appendix H) and returns it to Sample Receiving. The information on this form includes the lot number, PM, the subcontractor lab, the required analysis, the courier's tracking number and the date the sample was subcontracted. This form allows the PM to verify that the subcontracted analysis has been sent to the appropriate lab and to track the sample shipment.
 - 4.11.3.1 If samples are subcontracted via field services then the following must be done:

Shealy Environmental Services, Inc.

Page 27 of 59
Document Number: ME0013H-08

Effective Date: 5/8/2018

4.11.3.1.1 Columbia field service: Samples must be placed in a bag/box labeled with the name of the subcontract lab. The field services group leader must be informed that subcontract is ready for pick up.

- 4.11.3.1.2 Charlotte field service: The Charlotte office must be contacted ahead of time in order to arrange for pick-up of the subcontracted samples.
- 4.12 **Sample Return/Disposal** After preparation and analysis have been completed on a sample, it is returned to storage. Most samples are kept for a minimum duration of four (4) weeks before disposal. Others are kept longer per client request. The determination of what samples are ready to be disposed of is based on a color code system. Using a color code chart, the custodian removes and disposes of the samples received approximately during the sixth week prior to the current week (soils are dumped during the sixth week or afterwards). Exceptions to this include samples whose holding times are short and those that are consumed during analysis.
 - 4.12.1 Regardless of the method of disposal or final disposition, the event is recorded via the LIMS 5 ICOC system.
 - 4.12.2 Samples are either returned to clients or disposed of as either hazardous or non-hazardous waste via the ICOC. The Shealy Hazardous and Non-Hazardous Laboratory Waste Management Plan (ME0012A) contains the proper procedure as to the handling of sample disposal or transfer back to the client. In the event samples are part of a litigation process, disposal of the samples must only occur with the written approval of the legal authority, sample submitter, or sample data user. The following types of samples are returned to the client: samples containing PCB hits between 50 and 500ppm, radioactive samples, or if the client has requested the return of their samples.
 - 4.12.3 Radioactive samples, client requested samples These samples should be labeled with a "Return to Client" label upon receipt of the sample. Such samples will be returned with a new COC, filled out by sample receiving, listing the sample IDs, collection time/date, reason for return and lot #. These samples must be scanned out as Returned to Client in the ICOC. Samples requiring return must be pulled out of circulation and isolated in the designated return to client bin and listed as being held on the return to client list. The PM should be notified of samples that need to be returned to the client.
 - 4.12.4 Samples that have a PCB detection less than 500 ppm or samples for which the EHSO has given approval may be disposed at Shealy and placed in the PCB waste stream.
 - 4.12.5 If returning H-16 samples to the Savannah River Site (SRS), then an H-16 form must be filled out, and the PM must be notified when samples are ready for return by field services.

4.13 US EPA CLP Sample Receipt

- 4.13.1 *Chain of Custody* Each sample received must have a COC or a Traffic Report (TR). The information listed below should be available with each sample:
 - Case Number
 - CLP Sample Numbers
 - Sample Matrix

Shealy Environmental Services, Inc.

Page 28 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

- Concentration
- Sample Type
- Preservative
- Analysis
- Tag Numbers
- Station Location Identifier
- Collection Date/Time
- Sampler Initials
- Shipment for Case Complete
- Air bill Number
- COC Number
- 4.13.2 Form DC-1 At the time of sample receipt, an original Form DC-1 is completed contemporaneously for each sample shipping container. The form, as well as the air bill, is signed and dated by the sample custodian. The sample custodian records the cooler receipt temperature on both the DC-1, the chain of custody, and the associated air bill. Form DC-1 is completed to verify the presence or absence and the condition of the custody seals, air bills, COCs, TRs, sample tags, cooler temperature blanks and to verify the pH of any preserved samples. Any anomaly or discrepancy between the COC/TR and the sample labels is documented on Form DC-1. Also noted is the condition of the samples upon receipt, and the date and time of receipt.
 - **NOTE:** A separate DC-1 form must be filled out for ISM samples and for SOM samples. See Appendix C and D for the ISM and the SOM DC-1 forms.
- 4.13.3 *Sample Custody* A sample is considered in custody if:
 - It is in a person's possession; or
 - It is in view after being in possession; or
 - It is locked in a secure area after being in possession; or
 - It is in a designated secure area, accessible only to authorized personnel.
- 4.13.4 Sample Receiving A designated sample custodian (or designated backup custodian) is responsible for receiving all USEPA CLP samples.
 - 4.13.4.1 A thorough exterior check of the shipping container is performed to ensure that the custody seals are present and intact. Before cutting the custody seals on a cooler, inspect the seal for any custody seal numbers. These custody seal numbers are required to be listed on the DC-1 form for the cooler shipment.
 - 4.13.4.2 The sample cooler is then opened in the following manner to ensure that the person opening the cooler is not exposed to any fumes from potentially broken samples.
 - 4.13.4.2.1 If the cooler size permits, coolers will be opened inside of the sample receiving hood. If a cooler is too large to fit inside of the fume hood it must be opened directly in front of the fume hood.

Shealy Environmental Services, Inc.

Page 29 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.13.4.2.2 Coolers must be placed on the lift jack, no more than approximately 12" from the face of the fume hood sash, and raised such that the lid of the cooler is approximately half way between the lip of the hood and the certified sash opening. This sash is to be opened at the certified sash height during this process.

- 4.13.4.3 The temperature is immediately determined from the temperature blank, if present, before the cooler is unpacked. If a temperature blank is not present, the temperature will be taken from a *single* representative sample. Cooler IDs must be recorded in LIMS along with their associated temperatures.
- 4.13.4.4 Prioritize CLP samples according to hold times (24 hours or less (encores) and turn-around-time required.
- 4.13.4.5 The cooler contents are organized according to the COC/TR and all information is verified on the container labels and sample tags if present.
- 4.13.4.6 The sample custodian signs, dates and records the time on all forms (COCs, original TRs and air bills). The sample custodian also completes Form DC-1.
- 4.13.4.7 In the "sample condition" field on the COC/TR and the DC-1, the sample receiving custodian must note if samples are missing, pH requires adjustment, VOA vials contain air bubbles greater than 6 mm, sample containers are received broken, if there is a label or tag discrepancy or if there is any other discrepancy.

Note: Initials are not acceptable for signing forms.

- 4.13.5 Sample Delivery Group (SDG) The samples are assigned to a SDG at the time of receipt.
 - 4.13.5.1 The SDG number is the lowest alphanumeric EPA sample number received in the SDG. When several samples are received together in the first shipment, the SDG number will be the lowest sample number (considering both alpha and numeric designations) in the first group of samples received under the SDG. The same sample may be in an SDG in an ISM and an SOM lot (for example: the SOM sample designation is D03A1 and the ISM sample designation is MD03A1).
 - 4.13.5.2 An SDG is assigned for each lot of field samples received for a case, a maximum of 20 field samples within a case, or each 7 calendar day period (counting the receipt date) during which field samples in a case are received. For example: samples first received on Thursday are placed in an SDG which may also include samples received through the following Wednesday. For EPA Cases scheduled for a 7 day TAT, samples can only be added to the SDG for a period of 4 calendar days (counting the receipt date).

NOTE: Samples must not be added into an SDG on the 8th day (counting the receipt date) unless given permission by the CLP PM or the Technical Director.

Shealy Environmental Services, Inc.

Page 30 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

4.13.5.3 If an EPA case requires designated QC (noted on EPA schedule), then solid samples and aqueous samples need to be in separate SDGs.

- 4.13.5.4 If an EPA inorganic case has both total metals and/or mercury and dissolved/filtered metals and/or mercury, the total and dissolved samples need to be in separate lots/SDGs in LIMS5.
- 4.13.5.5 The sample receiving custodian will check for any e-mails from the technical director and/or CLP PM and if further information is required, the custodian will check the CLP Case Schedule located in the following location: P:\Lab Status\CLP_Case_Status\CLP_Scheduling before logging samples into LIMS.
- 4.13.5.6 If there are multiple modified analyses (MA) for one parameter, then each MA is placed into a separate SDG. Multiple MAs for different parameters may remain in the same SDG.
- 4.13.5.7 CLP Performance Evaluation (PE) samples **must be excluded** from the count of 20 samples comprising an SDG.
 - 4.13.5.7.1 If PE samples arrive ahead of their associated samples, then PE sample(s) will be logged into LIMS5 without any tests until the associated samples arrive. The PE samples will be labeled and placed in the Receiving walkin cooler. If the PE samples arrive on the same receipt date as the associated samples then log the PE samples into the SDG first. If there are over 20 samples and multiple PE samples have been received, then the PE samples are to be split among the sample lots. PE samples are not included in the designation of an SDG. The lowest alphanumeric regular sample must be used.
 - 4.13.5.7.2 In LIMS 5 the sample type must be changed to PT Sample, the PE box should be checked, and "PT" needs to be written in the comments section.
- 4.13.5.8 Additionally, if a sample with the same sample ID, but different analysis is received while the SDG is open during a 7 calendar day period, it will always be added to the same SDG containing that same ID, but as a separate line item to indicate that it was received on a different date/time.
 - **NOTE:** If a sample with the same sample ID requiring % solids is received after the initial receipt date, then % solids is logged in for the sample as mentioned above and a note stating that the % solids result should be obtained from the original sample is added to the comments.
 - 4.13.5.8.1 The information is then entered into the Shealy LIMS and a unique laboratory lot number is assigned to the samples. All sample tags, if present, are collected according to the SDGs and must remain with the COC/TR. Sample tags are recorded in the DC-1 form as well. Each tag is placed in a bag labeled with the SDG #. The tags are placed in order

Shealy Environmental Services, Inc.

Page 31 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

inside the bag as they are listed in the SDG. Sample tags for the same Case/SDG for multiple receipt days will go into one labeled bag.

- 4.13.5.9 A storage blank associated with volatile organic samples is logged into the LIMS and prepared for each SDG. Note: If a SDG has two volatile analyses, then two holding blanks will need to be logged into the SDG (e.g. TVOA and TVOA SIM). A blank is made for each VOA analysis/fraction, matrix and MA (modified analysis).
 - 4.13.5.9.1 Aqueous storage blanks are prepared as follows: Three preserved vials are filled with volatile-free water (from the VOA lab) and stored with the samples from the SDG.
 - 4.13.5.9.2 Solid storage blanks are prepared as follows: 5 mLs of volatile free water (from the VOA lab) is placed into each of three unpreserved VOA vials. A stir bar is added along with 5 grams (not more than 5.10 g) of Ottawa sand.
- 4.13.5.10 Ensure that the sample type is changed in LIMS5 for any holding blanks, PT samples, equipment blanks, rinsate blanks, field blanks, and trip blanks.
- 4.13.5.11 For organic MS/MSDs, check the appropriate samples under the analysis MS column in order to designate which sample should have an MS/MSD run on it. This must also be recorded first in the comment section in LIMS. If more than one designated QC (MS/MSD) is provided, make sure that they are logged into two separate SDGs. If a case requires designated lab QC and nothing is designated on the COC/TR contact the CLP PM or the technical director before logging in samples.
 - **NOTE:** EPA does not use the letter "O" therefore CLP Sample IDs must always be entered into the LIMS as a zero ("0")
- 4.13.6 *Verification of Aqueous Sample Preservation* At the time of sample receipt, sample receiving checks the pH of the sample and notes on Form DC-1 if the pH is ≤ 2 SU for metals or is ≥ 12 SU for cyanide samples. If cyanide sample pH(s) are not in range, the sample custodian needs to alert the CLP PM right away before preserving. Note the exact pH of the sample (example 1.5 SU), record the chemical IDs of the preservative and the pH strips used as well as preservation time and volume of preservative added.
 - 4.13.6.1 If a metals sample has not been properly preserved, sample receiving will adjust the pH of the metals sample. See section 4.9.7. This will be noted in the SDG narrative.
 - 4.13.6.2 Cyanide samples are not pH adjusted. The Sample Management Office (SMO) will be contacted for further instructions before proceeding with the preparation and analysis.
 - 4.13.6.3 The pH of TCLP and SPLP samples will not be adjusted.
- 4.13.7 Sample Receiving Review A final review by the sample receiving custodian occurs after the samples have been entered into LIMS 5 and before proceeding to the next lot. The custodian

Shealy Environmental Services, Inc.

Page 32 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

will perform a cursory on-screen level I review of the lot, but will not promote the lot. A level 1 review of the lot includes:

- 4.13.7.1 Ensuring that all information from the COC has been entered into LIMS correctly and completely.
- 4.13.7.2 Ensuring that the TR/COC and the DC-1 has been filled out completely and appropriately.

5. REFERENCES

- 5.1. Methods for the Chemical Analysis of Water and Wastes (MCAWW), EPA-600/4-79-020, March 1983.
- 5.2. <u>US EPA CLP SOW SOM Organic Superfund Analysis, Multi-Media, Multi-Concentration</u>, as referenced in the QAMP (ME0012K).
- 5.3. <u>US EPA CLP SOW ISM Inorganic Analysis, Multi-Media, Multi-Concentration</u>, as referenced in the QAMP (ME0012K).
- 5.4. <u>Shealy Quality Assurance Management Plan (QAMP)</u> ME0012K.
- 5.5. <u>EPA's SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods</u>, Revision 3, December 1996.
- 5.6. DoD/DOE Quality Systems Manual (QSM) for Environmental Laboratories, as referenced in the QAMP (ME0012K)...
- 5.7. "United States Department of Labor." *OSHA QUICK CARD: Hazard Communication Standard Pictogram.* Occupational Safety and Health Administration, n.d. Web. 24 Jan. 2017.

Shealy Environmental Services, Inc.

Document Number: ME0013H-08

Page 33 of 59
Effective Date: 5/8/2018

APPENDICES APPENDIX A: CHAIN OF CUSTODY STANDARD



Chain of Custody Record

Shealy Environmental Services, Inc. 106 Vantage Point Drive West Columbia, South Carolina 29172 Telephone No. (803) 791-9700 Fax No. (803) 791-9111

Number

							-						dab.co		(-	00,								
Client		Report to	Conta	ict											Telep	hone N	lo./E-	mail						Quote No.
Address			Sampler's Signature										Analy	sis (Att	ach lis	t if mor	e spac	e is ne	eded)			Page of		
City State Zip Code		X	X																					
Project Name		Printed	rinteu vaine																	Laboratory Lot Number				
Project Number	P.O No.	•	site		Ma	ıtrix				of C														
Sample ID / Description (Containers for each sample may be combined on one li	ne) Date	Time	G=Grab	Aqueous	Solid	Non- Aqueous		Unpres.	H2SO4	HNO3	БÜ	NaOH	5035 Kit											Remarks / Cooler I.D.
Turn Around Time Required (Prior lab approval re Standard Rush (Please Specify)	quired for expedited	ITAT)			sposa to Clie			Dispo	sal b	y Lab		Possible Hazard Identification (List any known hazards in the rema							ks)	QC Requirements				
1. Relinquished by			Date				Time	•				1. Re	eceive	d by							Date			Time
2. Relinquished by							Time	:				2. Re	eceive	d by							Date			Time
3. Relinquished by							Time					3. Received by				Date			Time					
4. Relinquished by			Date				Time					4. La	borato	ory R	eceive	d by					Date			Time
Note: All samp unle	les are retain ss other arran					ecei	ot						USE (eived o			:k) [] Y	N	Се	Pack		Re	ceipt Te	emp°C

Document Number: ME002OW-01

Shealy Environmental Services, Inc. Document Number: ME0013H-08 Page 34 of 59 Effective Date: 5/8/2018

APPENDIX A CONT'D: CHAIN OF CUSTODY CWA/NPDES

SHEAL	ì

CWA / NPDES Chain of Custody Record

Shealy Environmental Services, Inc. 106 Vantage Point Drive West Columbia, South Carolina 29172 Telephone No. (803) 791-9700 Fax No. (803) 791-9111

Number

Client								44444	shealylab.o											
·				Report to Co	ontact					Sampl	ler (Pri	nted I	Name)							Quote No.
Address				Telephone No. / Email							Field parameters (i.e., pH, temp, DO) can be recorded below							Page of		
City	State	Zip Code		Preservat	Preservative					П										Number of Containers
				1. Unpres.				/ZnA												Container Type: P=Plastic G=Glass
Project Name				2. NaOH 5. HCL 3. H2SO4 6. Sodium Thiosulfate																Preservative (use code on left) Lot No.
Project Number			P.O Number	r					_											LUI NU.
					g g	Ction	ted		— <u>։</u>											
Sample ID / Des (Containers for each s combined on o	ample	may be	Collection Date	Collection Time (military)	G=Grab C=Composite	Collection Sample Temp	Chlorinated Y./N	GW DW WW HW S=Salid	Analysis											
			Start																	Remarks / Cooler ID
			Finish		1															
			Start																	
			Finish		1															
			Start										 							
			Finish		1															
			Start																	
			Finish		1															
			Start																	
			Finish		1															
Turn Around Time Required (F	Prior lab	approval req	uired for expedi	ted TAT)	Sample	Disposa	al	•	QC F	equirer	nents									wn hazards in the remarks)
Standard Rush (Plea	se Spec	cify)			Retu	rn to Cli	ent 🔲	Disposal by Lab						n-Haza n Irrita	ardous nt		Flamr Unkno	nable own	ш	SDS Provided
Relinquished by / Samp	ler				Date			Time	1. Re	ceived	by						Date			Time
2. Relinquished by					Date			Time	2. Re	ceived	by						Date			Time
3. Relinquished by					Date			Time	3. Re	ceived	by						Date			Time
4. Relinquished by					Date			Time	4. Lal	oratory Received by					Date			Time		
			are retaine other arran					LAB USE O	ILY Check	а П	γ П	N F	lice P	ack		Recei	pt Ter	np.		Temp. Blank

Document Number: ME002OV-01

Shealy Environmental Services, Inc. Document Number: ME0013H-08

Page 35 of 59 Effective Date: 5/8/2018

APPENDIX B: SAMPLE RECEIPT CHECKLIST

Shealy Environmental Services, Inc.

Page 1 of 1

Document Number: ME0018C-13

Sample Receipt Checklist (SRC)

Client:			Cooler Inspected by/date: / Lot #:							
	fussint									
	□ No		SI							
			2. If custody seals present, were they intact and unbroken?							
		L IVA								
pH Strip	ID:		Chlorine Strip ID:erature upon receipt / Derived (Corrected) temperature upon receipt:							
Coolei I.	D / Origi	nai tempe	rature upon receipt / Derived (Corrected) temperature upon receipt.							
/^°C/^°C/°C/°C Method: □ Temperature Blank □ Against Bottles IR Gun ID: IR Gun Correction Factor:°C										
	Method of coolant: Wet Ice Ice Packs Dry Ice None									
iviculou	or coolar		3. If temperature of any cooler exceeded 6.0°C, was Project Manager Notified?							
□ Yes	☐ No	□ NA	PM was Notified by: phone / email / face-to-face (circle one).							
□ Yes	□ Nt-									
		□NA	4. Is the commercial courier's packing slip attached to this form?							
Yes	☐ No		5. Were proper custody procedures (relinquished/received) followed?							
☐ Yes	□ No		6. Were sample IDs listed on the COC?							
☐ Yes	□ No		7. Were sample IDs listed on all sample containers?							
☐ Yes	□ No		8. Was collection date & time listed on the COC?							
☐ Yes	□ No		9. Was collection date & time listed on all sample containers?							
☐ Yes	□ No		10. Did all container label information (ID, date, time) agree with the COC?							
☐ Yes	□ No		11. Were tests to be performed listed on the COC?							
			•							
□ Yes	□ No		12. Did all samples arrive in the proper containers for each test and/or in good condition							
			(unbroken, lids on, etc.)?							
□ Yes	□ No		13. Was adequate sample volume available?							
□ Yes	□ No		14. Were all samples received within ½ the holding time or 48 hours, whichever comes first?							
☐ Yes	□ No		15. Were any samples containers missing/excess (circle one) samples Not listed on COC?							
			16. For VOA and RSK-175 samples, were bubbles present >"pea-size" (1/4" or 6mm in diameter) in							
☐ Yes	□ No	□ NA	any of the VOA vials?							
☐ Yes	□ No		17. Were all DRO/metals/nutrient samples received at a pH of < 2?							
☐ Yes			18. Were all cyanide samples received at a pH > 12 and sulfide samples received at a pH > 9?							
			19. Were all applicable NH ₃ /TKN/cyanide/phenol/625 (< 0.5mg/L) samples free of residual							
☐ Yes	□ No	□ NA	chlorine?							
			20. Were client remarks/requests (i.e. requested dilutions, MS/MSD designations, etc)							
□ Yes	□ No	□ NA	correctly transcribed from the COC into the comment section in LIMS?							
□ Yes	□ No		-							
			21. Was the quote number used taken from the container label?							
Sample	Preserva	tion (N	Must be completed for any sample(s) incorrectly preserved or with headspace.)							
Sample(were received incorrectly preserved and were adjusted accordingly							
in sampl	e receivii	ng with _	(H2SO4, HNO3, HCl, NaOH) using SR #							
Time of	preservat	ion								
Sample(s)		were received with bubbles >6 mm in diameter.							
Samples	(s)		were received with TRC > 0.5 mg/L (If #19 is no) and were							
adiusted	accordin	gly in sar	mple receiving with sodium thiosulfate (Na ₂ S ₂ O ₃) with Shealy ID:							
		<i>8-7</i>								
SR barce	ode labels	s applied	by: Date:							
C										
Commer	us.									

APPENDIX C: FORM DC-1 -SOM02.4

FORM DC-1 SAMPLE LOG-IN SHEET

Lab Name		Page of	
Received By (Print Name)	Log-in Date		
Received By (Signature)			
Case Number	SDG No.	MA No.	

Ren	narks:	
1.	Custody Seal(s)	Present/Absent* Intact/Broken
2.	Custody Seal Nos.	
3.	Traffic Reports/Chain of Custody Records or Packing Lists	Present/Absent*
4.	Airbill	Airbill/Sticker Present/Absent*
5.	Airbill No.	
6.	Sample Tags Sample Tag Numbers	Present/Absent* Listed/Not Listed on Traffic Report/Chain of Custody Record
7.	Sample Condition	Intact/Broken*/ Leaking
8.	Shipping Container Temperature Indicator Bottle	Present/Absent*
9.	Shipping Container Temperature	
10	Does information on Traffic Reports/Chain of Custody Records and Sample Tags agree?	Yes/No*
11.	.Date Received at Lab	
12.	.Time Received	
	Sample Tags agree? Date Received at Lab	

		Corres	ı				
	EPA Sample #	Sample Tag #	Assig Lab #	ned	Remarks: Condition of Sample Shipment, etc.		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							

 $[\]mbox{*}$ Contact SMO and attach record of resolution

Reviewed By	Logbook No.
Date	Logbook Page No.

SOM02.4 (10/2016)

Form DC-1

APPENDIX D: FORM DC-1 -ISM02.4

FORM DC-1 SAMPLE LOG-IN SHEET

Lab Name		Page of
Received By (Print Name)	Log-in Date	
Received By (Signature)		
Case Number	SDG No.	MA No.

Remarks:					Corres	sponding	
Custody Seal(s) Custody Seal Nos.	Present/Absent* Intact/Broken		EPA Sample #	Aqueous/ Water Sample pH	Sample Tag #	Assigned Lab #	Remarks: Condition of Sample Shipment, etc.
3. Traffic Reports/Chain of Custody Records or Packing Lists 4. Airbill	Present/Absent* Airbill/Sticker	1 2 3					
5. Airbill No.	Present/Absent*	5					
6. Sample Tags Sample Tag Numbers	Present/Absent* Listed/Not Listed on Traffic Report/Chain of Custody Record	6 7 8 9					
7. Sample Condition 8. Shipping Container Temperature Indicator	Intact/Broken*/ Leaking Present/Absent*	10 11 12					
Bottle 9. Shipping Container Temperature	Yes/No*	13					
information on Traffic Reports/Chain of Custody Records and	ies/No-	15 16 17					
Sample Tags agree? 11. Date Received at Lab 12. Time Received		18 19 20					
		21					

^{*} Contact SMO and attach record of resolution

Reviewed By	Logbook No.
Date	Logbook Page No.

ISM02.4 (10/2016)

Form DC-1

Shealy Environmental Services, Inc.

Document Number: ME0013H-08

Page 38 of 59
Effective Date: 5/8/2018

APPENDIX E: SAMPLE STORAGE LOCATIONS

Analysis Category	Location	ID		
All analyses except volatiles	Sample Receiving	Walk-in Cooler #1		
All inorganic non-metal analyses	INM Laboratory	Walk-in Cooler #2		
Aqueous volatiles	Volatiles Laboratory	Walk-in Cooler #8		
Solid volatiles (MeOH and Screening Vials)	Volatiles Laboratory	Refrigerator/Freezer #4		
Solid volatiles (Encores and Low Level)	Volatiles Laboratory	Freezer #14		
CLP trace volatiles	Volatiles Laboratory	Refrigerator #18		
All other aqueous CLP volatiles	Volatiles Laboratory	Walk-in Cooler #8		
CLP solid volatiles	Volatiles Laboratory	Freezer #14		
CLP BNA/Pesticides/ Aroclors	Sample Receiving	Walk-in Cooler #1		

Shealy Environmental Services, Inc.

Page 39 of 59
Document Number: ME0013H-08

Effective Date: 5/8/2018

APPENDIX F: SAMPLE RECEIVING - SUMMARY OF PROCEDURES

NON-CLP CLIENT COOLER / SAMPLE LOGIN

See SOP for full instructions.

SAMPLE LOGIN PRIORITY

- EPA-CLP SOM/ISM
- COCs with **Short Holds**: Nitrate, Nitrite, Ferrous Iron, Hexavalent chromium (Cr⁶⁺), BOD
- Rush work
- 1. Open all coolers, remove, and sign COCs **RECORD TEMPERATURES.** Notify PM immediately if temperature is above 6°C either by phone, email or face-to-face.
- 2. Review COCs prioritize log-in.
- 3. Inspect contents notify PM immediately if bottles are broken.
- 4. Review collection dates/times and tests **Notify lab immediately for samples with holding times that** are in danger of expiration (less than 12 hours remaining).
- 5. Place sample bottles on counter, organize bottles according to the COC.
- 6. Verify correct sample ID's and number and type of bottles. **Notify PM immediately if bottles are missing (compared to COC).**
- 7. Aqueous Samples:
 - Verify correct pH and TRC for each sample as required.
 - Adjust pH with the proper acid or base (cyanide only) if required.
 - Check VOC vials for bubbles. If vials have bubbles record sample ID and number of vials w/bubbles.

Soil Samples

- Make up a **percent solids** snap cup for each sample. Consult PM before decanting any free standing water from the sample container. Use a wooden tongue depressor and add 5-10 grams to the snap cup. Mark SOM sample snap cup labels with a yellow highlighter.
- VOC vials w/stir bar are stored on their side in freezer in VOA prep lab.
- **Notify** Volatiles lab immediately if **Encore** samplers arrive.
- 8. Fill out Sample Receiving Checklist (SRC).
- 9. Create a new lot in LIMS 5.
 - Use **Quote Number** on COC if provided. Contact PM if in doubt about which quote to use.
 - Enter **Project Name**, **Project Number and PO Number** from COC if provided.

Shealy Environmental Services, Inc.

Page 40 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

- Check COC for **Rush TAT notify PM** that **Rush** samples have arrived.
- Check COC for any **Special Instructions** enter into comments in LIMS 5.
- Enter Sample ID's, collection date & time, bottle and tests as requested on COC Call PM with
 discrepancies!! Do not login metals if the correct list is not available note on communication
 form!!!
- Enter all COC numbers if more than one COC is sent.
- Scan COC and completed SRC, print sample labels.
- 10. Label sample bottles and % moisture snap cups.
- 11. Store **non VOC** sample bottles on the appropriately labeled shelves in the Sample Receiving Walk-in cooler.
- 12. VOC vial storage:

Aqueous samples

- The three-40 mL VOA vials are placed side by side according to sample ID starting at the lower left corner of the storage box and continuing from bottom to top.
- Store samples in walk-in cooler in Volatiles laboratory.

Soil Samples

- Store vials in each of three boxes: one box for methanol vials, one box for screening vials and one box for sets of two vials w/stir bars.
- Store in vials with stir bars (vials placed on their side) in freezer in Volatiles Prep Lab.
 - Alert VOC lab immediately when ENCORE soils arrive. If VOC personnel are not available
 place the samples in the VOA freezer.
- 13. Staple the COC and Sample Receiving Checklist (SRC), together and place in PM 'mail' box.

<u>CLP COOLER / SAMPLE LOGIN</u> See SOP for full instructions.

USEPA CLP – ISM SAMPLES

1. Form DC-1

 Sign and record date and time of sample receipt on DC-1 form – document any sample anomalies or discrepancies.

2. Sample Receipt

• Inspect cooler. Verify custody seals are present. Note on DC-1 if custody seals are missing.

Shealy Environmental Services, Inc.

Page 41 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

- Open cooler. Inspect contents. Note any samples that are broken on DC-1.
- **Measure temperature** of temperature blank if present. If no temp blank is present measure temperature of a representative sample. **Notify PM if temp is > 10** °C.
- Remove and setup samples according to COC or Traffic Report (TR)
- Make a copy of the TR. Sign and record date/time on all forms (COC, TR, and air bills). Fill
 out DC-1 form.
- Assign SDG (Sample Delivery Group) number. SDG number is the sample number of the
 first sample received in the SDG or the lowest sample number if multiple samples are
 received.

An SDG is assigned for:

- each case of field samples received,
- each 20 field samples within a case,
- or each 7 day calendar period during which field samples within a case are received

If the same sample ID is received over multiple days while the SDG is open during the 7 day calendar period, it will always be added to the same SDG containing that ID.

USEPA CLP – SOM SAMPLES

- Create a new lot in LIMS 5. Enter sample information.
- Enter **entire** Traffic Report Number in COC field.
 - Check the Test Key at the bottom of the Traffic Report to verify the correct tests: i.e. VOC vs. Trace VOC.
 - o If there is a **discrepancy** between the tests requested on the Traffic Report and the Scheduling Notification, login **tests requested** for the Case as listed on the **Scheduling Notification**.

Modified Analysis (MA)

- Log in Modified Analysis test from quote. If MA test is not available or in doubt about which test to login contact the CLP project manager immediately.
- Add MA number from Traffic Report to Comments.
 - o Soils: Log in pH for all SVOC, Pesticides, PCB's
- Verify VOC soil sample vials received contain water and methanol as required. Note the sample IDs on form DC-1 for the vials that do not contain the required water and methanol. The VOC department will add DI water and/or methanol to vials received empty as required.
- Print sample labels and label sample containers.

Shealy Environmental Services, Inc.

Page 42 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

• Collect all sample tags according to SDGs and store with the Traffic Report and air bill. Store in a **Ziploc Bag** labeled with **SDG number**.

Prepare VOC Storage Blank for each matrix and sample type: Soil, Aqueous and Trace VOC.
 Store with samples.

Aqueous & Trace VOC

- 1. 3-40 ml vials
- 2. Purged DI water from VOC lab

Soil

- 1. 2-40 mL vials with stir bars
- 2. Purged DI water from VOC lab
- 3. 4.9-5.1 g of Ottawa sand
- Store Volatile samples according to sample matrix and type in the Volatiles lab:
 - Trace VOC refrigerator
 - o Aqueous VOC refrigerator
 - Soil Freezer
- Alert VOC lab immediately when ENCORE soils arrive. If VOC personnel are not available place the samples in the VOA freezer.

Percent Moisture - Decant any standing water present and add 5 -10 grams soil to a labeled snap cup.

Shealy Environmental Services, Inc. Document Number: ME0013H-08

Page 43 of 59 Effective Date: 5/8/2018

APPENDIX G: SAMPLE RECEIVING COMMUNICATION

Shealy Environmental Services, Inc. Document Number: ME001US-01		Page 1 of 1 Effective Date: 11/03/2016 Expiry Date: 11/03/2021
	Sample Receiving Communication	Бари у Басс. 11/03/2021
Lot #		PM
☐ Quote missing analysis		
☐ TAT uncertainty		
☐ Other (please specify)		
PM Notified?	□ No	
Shealy Environmental Services, Inc. Document Number: ME001US-01	Sample Receiving Communication	Page 1 of 1 Effective Date: 11/03/2016 Expiry Date: 11/03/2021
Lot #		PM
PM Notified? □Yes, Date	□ No	
Shealy Environmental Services, Inc. Document Number: ME001US-01	Sample Receiving Communication	Page 1 of 1 Effective Date: 11/03/2016 Expiry Date: 11/03/2021
Lot #		PM
PM Notified?		

Shealy Environmental Services, Inc.

Page 44 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

APPENDIX H: SUBCONTRACT SHIPPING RECORD

Shealy Environemental Services, Inc. Document Number: ME0023M-01 Page 1 of 1 Effective Date: 03/16/2017 Expiry Date: 03/16/2022

Shealy Environmental Services, Inc.

Subcontract Shipping Record

Section 1: To be filled out by the PM

Date:		Project Manager:	
Lot Number:		·	
Subcontract Lab: Address:			
Tradioss.			
Phone Number: Test(s):			
resi(s):			
No. Samples:			
Turnaround Time:			
Shipping Method:		Select from drop-down menu	
simpping interior.		Select from drop down mend	
Special Instructions:			
Report Level:			
EDD:			
		•	
Section 2: 10 be fille	d out by Sample Receiving		
SR Custodian Initials:			
Date:			
COC Number:			
Tracking Numbers:			
(attach Subcontract CO	C if applicable)		

APPENDIX I: SHORT HOLD TIME SAMPLES

Short Holding Time Samples

Call the appropriate lab immediately if samples are received with holding times expiring within 12 hours:

INM - Ext. 128 or Ext. 113 Metals - Ext. 114 **BOD MBAS** Color **Nitrate Nitrite** Orthophosphate Hexavalent Chromium (Cr+6) Ferrous Iron Metals - 3030C

Shealy Environmental Services, Inc.

Page 46 of 59
Document Number: ME0013H-08

Effective Date: 5/8/2018

APPENDIX J: RADIOLOGICAL SURVEY METER OPERATIONS GUIDANCE

Eberline Model E-120E Geiger Counter

- 1. Turn the switch to the BATT check position. The meter should read within the BATT OK area.
- 2. To minimize fluctuation in readings, ensure that the RESPONSE knob is turned completely to the left (lowest setting).
- 3. Perform an operation check by exposing the detector to a radiation check source. With the detector still exposed to the check source, press the [RESET] button. The reading should drop rapidly to zero, then climb back up to the source reading once the [RESET] button is released.
- 4. The meter reads in 200 cpm increments. Take readings with the meter set to the appropriate scale factor (0.1X for most sample containers encountered). The meter reading must be multiplied by the scale factor to obtain the proper number.
 - a. Example 1: Meter needle at 200 cpm with meter set to the 0.1X scale factor signifies a reading of 20 cpm (200 x 0.1)
 - b. Example 2: Meter needle at 200 cpm with meter set to the 10X scale factor signifies a reading of 2000 cpm (200 x 10)

Ludlum Model 44-110 with Gas Flow Proportional Tritium Detector

- 1. Turn the switch to the BATT check position. The meter should read within the BATT OK area.
- 2. The meter is equipped with a toggle switch labeled F-S (fast response-slow response). To minimize fluctuation in readings, ensure that the toggle switch is in the S position.
- 3. Ensure that the P-10 counting gas is connected to the detector. Place the detector on a flat uncontaminated surface and turn the gas on by adjusting the flow-meter, located on the tanks regulator, until it reads between 3-4 liters per minute.
- 4. Check to ensure that the ON/OFF switch is in the ON position (switch pushed forward). You should hear gas purging from the detector if it is on. The count rate will increase as the detector purges until a maximum background level of approximately 400 cpm is reached. After obtaining a background reading, turn the detector OFF until the start of the survey.
- 5. Perform an operation check by exposing the detector to a radiation check source.
- 6. The meter reads in 20 cpm increments. Take readings with the meter set to the appropriate scale factor (1X for most sample containers encountered). The meter reading must be multiplied by the scale factor to obtain the proper number.
 - a. Example 1: Meter needle at 20 cpm with meter set to the 1X scale factor signifies a reading of 20 cpm (20 x 1)

Shealy Environmental Services, Inc.

Page 47 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

b. Example 2: Meter needle at 20 cpm with meter set to the 10X scale factor signifies a reading of 200 cpm (20×10)

NOTE: Dust on the detector's reading surface may impair the efficiency of the meter. A background count rate change of plus or minus 150 cpm may be due to dust accumulation rather than an actual change in background or low level contamination. A dust-remover spray must be used to remove dust on a regular basis. The spray must be 100% residue free.

Shealy Environmental Services, Inc.

Page 48 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

APPENDIX K: Walk-In Cooler #1 Sample Receiving

Shealy Environmental Services, Inc. Document Number: ME0019L-04

Walk-In Cooler #1 - SR

Page 1 of 53 Effective Date: 01/03/2017 Expiry Date: 01/03/2022

Required Temperature Range: 2.0 to 6.0°C

Date	Time	Analyst	Top Temp (°C) Therm. ID:	Adjusted Top Temp (°C) Adj. Factor:	Mid Temp (°C) Therm. ID:	Adjusted Mid Temp (°C) Adj. Factor:	Bottom Temp (°C) Therm. ID:	Adjusted Bottom Temp (°C) Adj. Factor:	Temp Within Range? Y/N	Comments
1/1/2017										
1/1/2017										
1/2/2017										
1/2/2017										
1/3/2017										
1/3/2017										
1/4/2017										
1/4/2017										
1/5/2017										
1/5/2017										
1/6/2017										
1/6/2017										
1/7/2017										
1/7/2017										

Temperatures must be taken twice daily, Monday - Saturday, at least 4 hours apart, and once on Sunday and Holidays

IF TEMPERATURES FALL OUTSIDE OF THE ACCEPTABLE RANGE QA MUST BE NOTIFIED WITH AN NCM

Note: Only page 1 is displayed here.

Shealy Environmental Services, Inc.

Document Number: ME0013H-08

Page 49 of 59
Effective Date: 5/8/2018

APPENDIX L: RADIOACTIVE MATERIAL SURVEY LOG

Shealy Environmental Services, Inc. Document Number: ME00103-01

Page 1 of 1 Effective Date: 5/11/2016 Expiry Date: 5/11/2021

RADIOACTIVE MATERIALS SURVEY LOG

¹ Eberline Gieger Count	ter (alpha, beta, and	d gamma measurements)	: Use 0.1X multiplier setting	Ludlum Gas Flow	Proportional Detector	(low-energy beta	/Tritium): Use 1X
multiplier setting.							

 $^2\mbox{Shipment(s)}$ cannot be accepted if survey results in readings at or above 20 CPM

Survey Date		
Survey Time		
Survey Conducted By		
Shealy Lot Number		
Countrate Meter Information	Eberline	Ludlum
Meter ID(s)		
Operation Check Performed? (Y/N)		
General Information	Yes	No
Client Screening Results and Shipping Information Present?		
Exterior Shipping Package/Cooler Intact?		
Interior Sample Containers Intact?		
Screening Information ¹	Eberline	Ludlum
Background Wipe Reading (CPM)		
Exterior Wipe Reading (CPM)		
Interior Wipe Reading (CPM)		
Shipment Acceptance ²	Yes	No
Shipment Accepted?		
If shipment not accepted, is the package properly isolated and has the RSO been contacted?		

APPENDIX M: Hazard Communication Standard Pictogram

HCS Pictograms and Hazards

Health Hazard



- Carcinogen
- Mutagenicity
- Reproductive Toxicity
- Respiratory Sensitizer
- Target Organ Toxicity
- Aspiration Toxicity

Flame



- Flammables
- Pyrophorics
- Self-Heating
- Emits Flammable Gas
- Self-Reactives
- Organic Peroxides

Exclamation Mark



- Irritant (skin and eye)
- Skin Sensitizer
- Acute Toxicity (harmful)
- Narcotic Effects
- Respiratory Tract Irritant
- Hazardous to Ozone Layer (Non-Mandatory

Gas Cylinder



Gases Under Pressure

Corrosion



- Skin Corrosion/Burns
- Eye Damage
- Corrosive to Metals

Exploding Bomb



- Explosives
- Self-Reactives
- Organic Peroxides

Flame Over Circle



Oxidizers

Environment (Non-Mandatory)



Aquatic Toxicity

Skull and Crossbones



Acute Toxicity (fatal or toxic)

OSHA 3491-02 2012

Shealy Environmental Services, Inc.

Document Number: ME0013H-08

Page 51 of 59
Effective Date: 5/8/2018

Shealy Environmental Services, Inc.

Page 52 of 59
Document Number: ME0013H-08

Effective Date: 5/8/2018

APPENDIX N: IR Gun Thermometer Quarterly Calibration Log

Shealy Environmental Services, Inc. Page 1 of 1
Document Number: ME001K1-05 Effective Date: 12/21/2017

IR Gun Thermometer Quarterly Calibration

Date: IR Gun ID:

Temperature Point	NIST Therm. ID	NIST Reading (°C)	IR Gun Reading (°C)	Adjustment (+/-°C)	Comments (Retirement Date, High, Mid, Low)
Ambient				0.0	
SR Walk-in				0.0	
Water & ice				0.0	

^{*}The adjustment for any temperature point should be no greater than \pm 1°C. Notify QA if this criterion is not met.

Adjustment Factor for IR Gun Thermometer = 0.0 (only report to one decimal place)

Adj. Factor for IR Gun Therm. = [(ambient adjustment) + (SR walk-in adjustment) + (water & ice adjustment)]

Calibration Instructions:

Obtain three 1-liter wide mouth amber bottles from the bottle prep area. Fill two 1-liter wide mouth amber bottles approximately 2/3 full of water for the 'ambient' and 'SR walk-in cooler' points. Fill one 1-liter wide mouth amber bottle with ice for the 'water and ice' point. Add approximately 50 grams of NaCl to the bottle containing ice and fill 2/3 full with water. The salt is used to depress the temperature below 0°C. Affix Shealy sample labels on each bottle below the water line. Place the SR walk-in cooler bottle in a safe area inside the SR walk-in cooler where it will not be disturbed. Put the ambient bottle and the ice/water/NaCl bottle in a safe area in SR. When taking the temperature with the IR gun, remember to aim the IR gun at the container label for the most accurate recording. Allow at least one hour for equilibration. Put the NIST traceable reference thermometer in the 'ambient' bottle and allow the reference thermometer to come to equilibrium. Read the temperature with the IR gun on the bottle by holding the gun ~8" from the label. Record all temperatures.

Place the reference thermometer in the 'water and ice' bottle and allow the reference thermometer to come to equilibrium. Read the temperature with the IR gun on the bottle by holding the gun ~8" from the label. Record all temperatures. Place the reference thermometer in the 'SR walk-in cooler' bottle in the walk-in and allow the reference thermometer to come to equilibrium for approximately thirty minutes. While physically in the walk-in cooler, read the temperature with the IR gun on the bottle by holding the gun ~8" from the label. Record all temperatures.

Note: The last recorded digit represents the increments marked on that thermometer. If a reading appears to fall between two increments, the closest increment is chosen and reported.

Example: a thermometer with 0.5° increments will be recorded as 3.5° C with the knowledge that the reading was closest to the 3.5° increment.

Adjustments are derived from the difference between the subject thermometer and the NIST thermometer.

The Adjustment Factor for the IR Gun Thermometer must be added to the apparent reading of the thermometer for all subsequent recordings.

Note: Once verification is completed, please save document and send QA an email to let us know that it is finished.

QA Verified by: Date: Shealy Environmental Services, Inc.

Page 53 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

APPENDIX O: IR Gun Thermometer Daily Verification Log

Shealy Environmental Services, Inc.

Page 1 of
Document Number: ME001N9-04

Effective Date: 12/21/201

IR Gun Thermometer Daily Verification

Date	Analyst	Reference Thermometer ID	Reference Thermometer Reading (°C)	IR Gun Thermometer ID	IR Gun Thermometer Reading (°C)	Pass / Fail (± 0.5°C)	Comments
			otion asset has reaformed				

^{*}Daily reading must be \pm 0.5°C or new quarterly verification must be performed.

Shealy Environmental Services, Inc.

Page 54 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

APPENDIX P: SR Balance Verification Log

Shealy Environmental Services, Inc.

Document Number: ME0024U-01

Effective Date: 3/29/2017
Expiry Date: 3/29/2022

BALANCE #13-1224 VERIFICATION LOG

		MAN		: Mettler Toled		ML802E/03	SERIAL # B			
	Weig	ghts		1.0g	10.0g	30.0g	50.0g	100.0g	150.0g	
	Toleranc	e Limits		0.99g - 1.01g	9.99g – 10.01g	29.97g – 30.03g	49.95g – 50.05g	99.90g – 100.10g	149.85g - 150.15g	
Date	Time	Analyst	Weight Set #							Pass Y/N

Note: If Value Is Out Of Tolerance Limits, Re-zero And Repeat Balance Verification. If Still Out Of Limits, verify weight. If still out of limits, Contact QA

Shealy Environmental Services, Inc. Document Number: ME0013H-08

Page 55 of 59 Effective Date: 5/8/2018

APPENDIX Q: H-16 Form

-16 NPDES Sample Return Form			DATE OF RETURN:				
FROM: SHEALY ENVIRON LOG VANTAGE POINT DR MEST COLUMBIA, SC 29: POINT OF CONTACT: GRANT WILTON 803-791-9700	IIVE	NC	TO: SAVAI SAVANNA AIKEN, SC POINT OF SIOBHAN 803-952-6	SOLUTIONS, LLC			
SRS SAMPLE ID	SHEALY SAMPLE I	CONTA		APPROXIMATE SAMPLE VOLUME	PRESERVATIVE		
Relinquished by (Shealy	Representative): D	ate	Received By (SRNS Representative):	Date		

Shealy Environmental Services, Inc.

Page 56 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

REVISION HISTORY

Original Document #: S-AD-001 Rev 17

Rev 17 to Rev 01

-changes were documented via tracked changes in EQLIMS

Rev 01 to Rev 02

- -Sections 3.2, 3.3 and 3.4 were added
- -Section 4.6 added that samples submitted for metals analysis requiring preservation at the time of receipt are to be noted in the comments of the sample receiving module in LIMS
- moved statement (to "Note") about samples being segregated and held in Sample Receiving
- added a note further describing the waiting period required after preservation
- added "Additionally, sample preservations must be performed inside of the fume hood located in the Sample Receiving area."
- -Section 4.13.5.1 & 5.4 added further describing the process by which coolers are opened which contain DOE samples
- -Section 7.4 updated QAMP reference
- -Appendix A updated forms to current versions

Rev 02 to Rev 03

- -Section 2.1 Changed # of full time custodians from 2 to 3
- -Section 4.3 Added: "If the temperature is greater than 6C, the custodian must notify the PM by phone, email or face-to-face immediately." and "...the samples are organized and checked for proper preservation (pH and TRC, as needed)..."
- -Section 4.6 Added: "The sample custodian should notify the project manager either by phone, email or face-to face." and "NOTE: Be careful not to over-dilute samples when adjusting the pH." and "Add small amounts of sodium thiosulfate until the chlorine is < 0.2 mg/L." and "Test strips' chemical lot IDs are also noted on the SRC."
- -Section 4.18 Added: "..but as a separate line item to indicate that it was received on a different date/time." and "Tags are recorded in the DC-1 form as well."
- -Section 5.2 Added: "...and pH of preserved samples."
- -Section 5.4 Added: "...but as a separate line item to indicate that it was received on a different date/time."
- -Section 6.1 Updated to reflect current water system
- -Sections 7 Updated references
- -Appendix B- Updated to current form
- -Appendices C through J Replaced with same tables from QAMP current revision
- -Appendices K Replaced with current 02.3 Form DC-1
- -Appendix L Updated ID of sample storage locations
- -Appendix M Added: "Notify PM immediately if temperature is above 6C either by phone, email or face-to face."

Rev 02 to Rev 03

- -Section 2.1 Changed # of full time custodians from 2 to 3
- -Section 4.3 Added: "If the temperature is greater than 6C, the the custodian must notify the PM by phone, email or face-to-face immediately." and "...the samples are organized and checked for proper preservation (pH and TRC, as needed)..."
- -Section 4.6 Added: "The sample custodian should notify the project manager either by phone, email or face-to face." and "NOTE: Be careful not to over-dilute samples when adjusting the pH." and "Add small amounts of sodium thiosulfate until the chlorine is < 0.2 mg/L." and "Test strips' chemical lot IDs are also noted on the SRC."
- -Section 4.18 Added: "..but as a separate line item to indicate that it was received on a different date/time." and "Tags are recorded in the DC-1 form as well."
- -Section 5.2 Added: "...and pH of preserved samples."
- -Section 5.4 Added: "...but as a separate line item to indicate that it was received on a different date/time."
- -Section 6.1 Updated to reflect current water system
- -Sections 7 Updated references
- -Appendix B- Updated to current form
- -Appendices C through J Replaced with same tables from QAMP current revision
- -Appendices K Replaced with current 02.3 Form DC-1
- -Appendix L Updated ID of sample storage locations
- -Appendix M Added: "Notify PM immediately if temperature is above 6C either by phone, email or face-to face."

Shealy Environmental Services, Inc.

Page 57 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

- -Section 4.3 (3rd paragraph) Deleted: "The custodian will complete the relinquished by time field when they sign the space marked for laboratory receipt."
- -Section 4.12 Added Note
- -Section 4.13 Added: "Radioactive Sample Handling" to the title so that all rad samples are handled in this manner
- Section 4.14 Removed "A Sample Acceptance Policy Form (F-QA-115) is provided with every bottle order and to walk-in Field personnel obtaining containers previous to sampling." and reference to Appendix M.
- Section 4.14.1 (including Sections 4.14.1-11) Added
- Appendix M USEPA CLP-SOM Samples section Changed: "contact Kerry" to "contact the CLP project manager"
- Appendix M USEPA CLP-SOM Samples section Updated the VOC soil sample procedure
- Appendix P Sample Acceptance Policy Removed
- -Appendix Q changed to P and R changed to Q.

Rev 04 to Rev 05

- -Formatting of entire document changed from large paragraphs to outline
- -Reorganized entire document
- -The following sections contain updated info, re-written info (for clarity) or contain added info: 2.2, 3.2, 4.1 through 4.18, 5.1 through 5.7, 61 through 6.6
- -Updated Appendix B, M, N, P
- -Added Appendix R, S

Rev 05 to Rev 06

- -Updated references to ISM and SOM to 02.4 throughout
- -Section 2.2.1 Added section
- -Section 3.1.2.1 Added to chose hazardous containers in LIMS; apply hazard stickers to bottles, SDS procedure
- -Sections 3.1.2.2, 4.3.1.3 & 4.3.2.3 Added sections
- -Sections 4.3.3.2.1.2 & 4.3.3.2.2.2 Added to document IR gun ID
- -Sections 4.3.3.2.1.3 & 4.3.3.2.2.3 Added section
- -Section 4.3.4.2 Added adjust temperature and record along with IR gun ID and whether or not cooler received on ice
- -Section 4.3.6.2.1.1 Defined "incorrect preserved", added to record if multiple samples are created from incorrectly preserved sample and added that separate container is always made for volatiles
- -Section 4.3.6.2.5 Added additional information parentheses to each sub-section; added Notes
- -Section 4.3.6.2.9 Added to compare bubble size to measurement device
- -Section 4.3.6.2.10 Added clarifying info concerning client requests
- -Section 4.8.1 Changed section to note on the SRC and transfer to correct container
- -Section 4.8.4.1 Added to enter "field filtered" in comments section
- -Section 4.8.4.2 Added to enter "lab to filter" in comments section; added Note
- -Section 4.8.6 Added to contact volatiles employee before leaving for the day
- -Sections 4.8.7, 4.9.2 & 4.9.3 Added sections
- -Section 4.10.1 Added Note
- -Section 4.10.4 Added section
- -Section 4.11.3.1 Clarified procedure for initial weight of snap container
- -Section 4.11.3.2 Added more instructions on how to prepare a % solids container
- -Section 4.13.3 Added where to save survey log
- -Sections 4.13.4, 4.17.2.6, 5.2 & 5.4.8.2- Added Note
- -Section 4.13.6 Added section
- -Section 4.15.2 Added: "Volatile samples are stored in separate boxes by test as well."
- -Section 4.17 Added: "The samples should be scanned out as "Subcontracted" in the ICOC system prior to shipping."
- -Section 4.17.3.1 Added section
- -Section 4.18.1 Added the types of samples returned to the client
- -Sections 4.18.2, 4.18.3, 4.18.4, 5.4.7, 5.4.8.3.1& 5.4.8.3.2 Added sections
- -Sections 5.4.8.1 & 5.4.8.2 Clarified placing samples in SDG
- -Sections 7.2 & 7.3 Updated CLP references
- -Section 7.6 Updated DoD reference
- -Section 7.7 Added reference
- -Appendices Updated forms where needed; added appendix T, U, V, W, X and Y
- -Section 5.4.8.4.1 Clarified procedure for sample tags
- -Sections 5.4.9, 5.4.10 Added sections
- -Section 5.7 Added use of colored dots to monitor length of storage

Shealy Environmental Services, Inc.

Page 58 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

- -Section 5.7.1 Clarified samples are stored in VOA walk in
- -Section 5.7.3 Updated storage blank procedure

Rev 06 to Rev 07

- -Section 4.3.6.2.2 Added note concerning segregating coolers in a shipment that are above 6 degrees C
- -Section 4.6.3.1.1.1 & 4.6.3.1.1.2 Added sections outlining test strips to be used
- -Section 4.6.3.1.2.2 Added reference to appendix Z
- -Section 4.6.3.4.2 Added a pH > 9 is required for sulfide samples
- -Section 5.1 Added case number, air bill number and COC number
- -Section 5.2 Added "The sample custodian records the cooler receipt temperature on both the DC-1 and the associated air bill."
- -Section 5.4.5 Added: "and sample tags if present."
- -Section 5.4.7 Section re-written
- -Section 54.8.2 Clarified how to count calendar days; added note
- -Section 5.4.8.4 Clarified what metal analyses need to be in separate lots
- -Section 5.4.8.5 Section re-written; deleted note concerning calendar days
- -Section 5.4.8.6 Added section
- -Section 5.4.8.8 = Added note concerning % solids
- -Section 5.4.9, 5.4.9.1 & 5.4.9.2 Added sections
- -Section 5.4.11 Added: "If more than one designated QC (MS/MSD) is provided, make sure that they are logged into two separate SDGs.", added Note
- -Section 5.5 Changed pH for cyanide samples from 10 to 12, Added: ". If cyanide sample pH(s) are not in range, the sample custodian needs to alert the CLP PM right away before preserving."
- -Section 5.7.1 Section re-written
- -Section 5.7.3 Deleted section on storage blank
- -Appendix B Updated form
- -Appendix E Added PFAS and 524.2 sections
- -Appendix M Added: "See SOP for full instructions."

Rev -07 to Rev-08 Effective Date: 5/7/2018

- General formatting and grammatical changes throughout entire document.
- Section 2.2- Section added
- Section 3.3- Added requirement to wear cut-proof gloves if coolers contain broken glass.
- Section 3.4- Section added
- Section 3.5- Section added
- Section 3.6- Section added
- Section 3.7- Section added
- Section 3.8- Added hazard identification procedures in subsections 3.8.1 through 3.8.5.
- Section 3.10- Section added
- Section 3.10.4 Changed wording to reflect that if an SDS is received, the SDS must be scanned into LIMS5
- Section 3.12 Added reference to Radiation Safety Plan
- Section 4.1.2- Section added
- Section 4.2 Clarified that only sample containers associated with tests need to be scanned in the ICOC
- Section 4.4.2 Updated where volatiles samples are stored; updated ICOC requirements
- Section 4.4.5 Added CLP sample storage info moved from section 4.5
- Section 4.5.1 Added holding time notification procedure
- Section 4.8 Removed statement regarding the use of volumetric flasks for preparation of reagents.
- Section 4.8 Added note in regards to preparation of reagent volumes based on usage.
- Section 4.8 Added sodium thiosulfate to list of reagents.
- Section 4.8.3 Changed narrow range pH paper to wide-range pH paper.
- Section 4.8.4 Note added
- Section 4.8.5 Added "Purchased from any manufacturer that can provide a certificate of analysis. Note manufacturer expiration date."
- Sections 4.8.5.1, 4.8.6, 4.8.7 & 4.8.8- Adjusted solution preparation instructions to increase volume made. Added "this reagent expires 6 months from the date of preparation".
- Section 4.9.1.6.2 Added: "single" representative sample container should be used
- Section 4.1.9.4 Section added
- Section 4.9.1.5- Section added
- Section 4.9.1.6.3 Identified information requiring documentation on the SRC.

Shealy Environmental Services, Inc.

Page 59 of 59

Document Number: ME0013H-08

Effective Date: 5/8/2018

- Section 4.9.1.6.4 Identified information requiring documentation on the COC.
- Section 4.9.1.7 Updated method of notification for samples received with temperature >6°C.
- Section 4.9.1.8 Clarified custody documentation requirements for samples received via commercial courier.
- Section 4.9.2.1 Clarified custody documentation requirements for samples received directly from client. Added note.
- Section 4.9.2.1- Removed information regarding custodian authorization to receive payments from clients. Information to be incorporated into a separate company policy per the CEO.
- Section 4.9.2.3 Section added
- Section 4.9.3.3 Added section instructed field technicians to take temperature of coolers immediately
- Section 4.9.3.4 Added: "left in a conspicuous manner."
- Section 4.9.5 Changed section header to read "Using the SRC to Assess Sample Acceptance Criteria...".
- Section 4.9.5.1- Added "The SRC is a form used to assess sample acceptance criteria...".
- Section 4.9.5.2 Added "SRC records are scanned into LIMS5..."
- Section 4.9.5.3.1 Added if custody seals are present to note this on the SRC
- Section 4.9.6 Changed section header to read "Thermal Preservation of Samples".
- Section 4.9.6.1 Added reference to analytical methods list
- Section 4.9.6.2.2 Added sample condition communication procedure.
- Section 4.9.7 Changed section header to read "Chemical Preservation of Samples". Added notes at end of completed section.
- -Section 4.9.7.2.1 Deleted: "narrow range" and "pH paper"
- Section 4.9.7.2.2- Chlorine strip detection range added.
- Section 4.9.7.4- Updated documentation requirements concerning sample preservation adjustments.
- Section 4.9.7.4 Added requirement to document time of preservation.
- Section 4.9.7.5 Added preservation notification requirements.
- Section 4.9.7.6.1.4 Updated list of analyses requiring chlorine check
- Section 4.9.7.6.1.5 Added section concerning notification of INM when chlorine is present
- Section 4.9.7.6.1.6 Added: "For all other samples..."
- Section 4.9.8.1 Added procedure for treatment of dissolved metals samples
- Section 4.9.8.2 Added procedure for filtration of orthophosphate samples
- Section 4.9.9 Added communication of client specified information procedures.
- Section 4.9.10 Added storm water sample micro analysis instructions
- Section 4.9.11.3 Added trip blank temperature documentation information.
- Section 4.9.11.4 Added section concerning bulk volatile sample procedures
- Section 4.9.12.5 Added: within 48 hours "of collection"
- Section 4.9.12.6 Added: "soil kit" and "and the volatiles lab should be notified."
- Section 4.9.16.1.4 Deleted requirement for peer reviewer when placing bar code labels on containers
- Section 4.9.17 Added to the note: "and packing materials (bubble wrap, etc.)"
- Section 4.10.2.1 Added: "beside the fume hood in SR"
- Section 4.11.2.5 Added to place custody seals on cooler
- Section 4.11.2.6 Added courier pick up locations
- Section 4.12 Updated sample disposal schedule
- Section 4.13.2 Added that the DC-1 should be completed contemporaneously and that the temperature should be recorded on the chain as well
- Section 4.13.4.1 Added instructions for treatment of the custody seal
- Section 4.13.4.3 Added temp is taken from a single representative sample
- Section 4.13.5.7.1 Updated procedures for handling PE samples
- Section 4.13.5.8.1 Added: ". Sample tags for the same Case/SDG for multiple receipt days will go into one labeled bag.
- Section 4.13.5.9 Added note
- Section 4.13.5.9.1 Moved blank made for VOA to section 4.13.5.9 note
- Section 4.13.5.11 Added instructions concerning designated lab QC
- Section 4.13.7 Changed from promoting lot to review to not promoting the lot
- Appendices Updated where needed

SHEALY ENVIRONMENTAL SERVICES, INC.

STANDARD OPERATING PROCEDURE

Determination of Per- and Polyfluoroalkyl Substances (PFAS) by LC/MS/MS (Isotope Dilution)

OSM 5.1 Table B-15 (EPA 537 MOD ID)

6/18/2018 1:10:00 PM

Danu JU right

Daniel J. Wright

Laboratory Director

6/19/2018 9:25:45 AM

Wendy Plessinger

Quality Assurance Officer

6/18/2018 5:26:11 PM

Robert Zhu

Technical Director

6/19/2018 11:35:04 AM

Bradley E. Belding

Operations Director

Proprietary Information Statement:

This document has been prepared by and remains the sole property of Shealy Environmental Services, Inc. It is submitted to a client or government agency solely for its use in evaluating Shealy's qualifications in connection with the particular project, certification, or approval for which it was prepared. This document is to be held proprietary to Shealy.

The user agrees by its acceptance or use of this document to return it upon Shealy's request and to not reproduce, copy, lend, or otherwise disclose or dispose of the contents, directly or indirectly. The user also agrees to not use it for any purpose other than that for which it was specifically furnished. The user agrees that access to this document shall not be given to consultants or others outside of the user's organization when those parties are involved in the evaluation process, unless those parties also specifically agree to these conditions.

TABLE OF CONTENTS

1	SCOPE AND APPLICATION	3
2	SUMMARY OF METHOD	3
3	DEFINITIONS	4
4	INTERFERENCES	6
5	SAFETY	6
6	EQUIPMENT AND SUPPLIES	7
7	REAGENTS AND STANDARDS	9
8	SAMPLE COLLECTION, PRESERVATION AND STORAGE	14
9	QUALITY CONTROL	14
10	CALIBRATION AND STANDARDIZATION	
11	PROCEDURE	20
12		
13	METHOD PERFORMANCE	26
14	POLLUTION PREVENTION	27
15	WASTE MANAGEMENT	27
16	REFERENCES	27
AP	PENDIX A: TABLES	28

Shealy Environmental Services, Inc.

Page 3 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

1 SCOPE AND APPLICATION

1.1 The main body of this SOP describes a modified version of EPA Method 537, a Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS) method for the determination of selected Perand Polyfluorinated Alkyl Substances (PFASs) in aqueous and solid samples using isotope dilution (ID) quantitation. This method is referred to as 537 MOD-ID (aqueous, aqueous serial dilution, and solid) Refer to Table 1 for target analytes.

1.2 The requirements contained in this SOP conform to those presented in the Department of Defense-Quality Systems Manual (DoD-QSM) Version 5.1, Table B-15 (January 2017), which are listed in Appendix F of this SOP, for reference.

2 SUMMARY OF METHOD

- 2.1 Method 537 MOD Isotope Dilution ((ID); aqueous): A 250-mL water sample is fortified with surrogates (SUR) and passed through a solid phase extraction (SPE) cartridge (Phenomenex Strata-XL-AW or equivalent) to extract the method analytes and SUR. The compounds are eluted from the Strata-XL-AW cartridge with 4-mL of methanol and 4-mL of ammonia-methanol (0.3%). Samples are then filtered by SPE (Envi-Carb), with a tube rinse of 1-mL of clean MeOH. With the SPE-Envi-Carb tube rinse, the final extract volume is approximately 9mL. An aliquot of the extract is fortified with internal standards (IS). 10-μL of the fortified aliquot is injected on an LC equipped with a C18 column that is coupled to an MS/MS detector. The analytes are separated and identified by comparing the acquired mass spectra and retention times to the reference spectra and retention times for calibration standards acquired under identical LC/MS/MS conditions. The concentration of each analyte is determined by using the internal standard isotope dilution technique.
- 2.2 Method 537 MOD Isotope Dilution (ID; solids): Approximately 1g of solid sample is mixed with 8mL of methanol containing surrogates (SUR). It is shaken on an orbital shaker and then sonicated and centrifuged. The extract is filtered by SPE-Envi-Carb, with two tube rinses of 1mL of clean MeOH each. The final extract volume following the filtration step is approximately 10mL. An aliquot of the extract is fortified with internal standards (IS). 10-μL of the fortified aliquot is injected on an LC equipped with a C18 column that is linked to an MS/MS detector. The analytes are separated and identified by comparing the acquired mass spectra and retention times to the reference spectra and retention times for calibration standards acquired under identical LC/MS/MS conditions. The concentration of each analyte is determined by using the internal standard isotope dilution technique. See Appendix B for specific procedures for preparing and analyzing solid samples by 537 MOD ID.
- 2.3 Method 537 MOD ID-Serial Dilution (MOD-ID-SD): Samples of known high PFAS concentrations, such as AFFF pure product formulations, can be prepared by serial dilution instead of SPE, with documented project approval. The sample serial dilutions will be prepared in 96% MeOH: 4% water. IS and SUR will be spiked into the diluted sample (not the original sample collected) in the preparation vial. Any target analytes found to be ND in any samples shall be spiked at the LOQ level (post-spike) in those samples at the dilution reported, and analyzed again. Recovery for the post-spiked analytes must fall within 70-130% of the expected value; if these criteria are not met, the post-spike analysis will be repeated at successively higher dilutions until recovery is acceptable. The spiking concentration will be used to calculate the project-specific LOQ for each analyte. 10-μL of the prepared dilution aliquot is injected on an LC equipped with a C18 column that is coupled to an MS/MS detector. The analytes are separated and identified by comparing the acquired mass spectra and retention times to the reference spectra and

Shealy Environmental Services, Inc.

Page 4 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

retention times for calibration standards acquired under identical LC/MS/MS conditions. The concentration of each analyte is determined by using the internal standard isotope dilution technique. See Appendix C for specific procedures for preparing and analyzing serial dilution samples by 537 MOD ID.

3 DEFINITIONS

- 3.1 Analysis Batch A set of samples that is analyzed on the same instrument during a 24-hour period, including no more than 20 field samples, that begins and ends with the analysis of the appropriate Continuing Calibration Verification (CCV) standards. Additional CCVs may be required depending on the length of the analysis batch and/or the number of field samples.
- 3.2 Collisionally Activated Dissociation (CAD) The process of converting the precursor ion's translational energy into internal energy by collisions with neutral gas molecules to bring about dissociation into product ions.
- 3.3 Continuing Calibration Verification (CCV) A standard prepared from the same parent standard as the initial calibration containing internal standard(s) and surrogate(s). The CCV is analyzed periodically to verify the accuracy of the existing calibration for those analytes.
- 3.4 Extraction Batch A set of up to 20 field samples (count does not include QC samples) extracted together by the same person(s) during a work day using the same lot of SPE devices, solvents, surrogates, internal standards and fortifying solutions. Required QC samples include Method Blank, Laboratory Control Sample, Matrix Spike, and either a Field Duplicate or Matrix Spike Duplicate.
- 3.5 Internal Standard (IS) A pure chemical added to an extract or standard solution in a known amount(s) and used to measure the relative response of other method analytes and surrogates that are components of the same solution. The internal standard must be a chemical that is structurally similar to the method analytes, has no potential to be present in water samples, and is not a method analyte. For the 537 MOD ID method, the IS is used to monitor consistency of instrumentation performance.
- 3.6 Surrogate (SUR) A pure chemical which chemically resembles method analytes and is extremely unlikely to be found in any sample. This chemical is added to a sample aliquot (field and QC) in known amount(s) before the extraction and analysis processes. The purpose of the SUR is to monitor method performance from extraction to final chromatographic measurement. For the 537 MOD ID method, the SUR is used for measuring the relative response and quantification of other method analytes.
- 3.7 Limit of Detection (LOD) An estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte- and matrix-specific and may be laboratory-dependent. An LOD is the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.
- 3.8 Limit of Quantitation (LOQ) Also referred to as the lower limit of quantitation (LLOQ). Formerly defined by the laboratory as the Practical Quantitation Limit (PQL). The LOQ represents the minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence. An LOQ is the lowest concentration that produces a quantitative result within specified limits of precision and bias. For DoD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard.

Shealy Environmental Services, Inc.

Page 5 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

3.9 Field Duplicates (FD1 and FD2) – Two separate samples collected at the same time and place under identical circumstances, and treated exactly the same throughout field and laboratory procedures. Analyses of FD1 and FD2 give a measure of the precision associated with sample collection, preservation, and storage, as well as laboratory procedures.

- 3.10 Trip Blank (TB) An aliquot of reagent water that is placed in a sample container in the laboratory and treated as a sample in all respects, including shipment to the sampling site, exposure to sampling site conditions, storage, preservation, and all analytical procedures. The purpose of the TB is to determine if method analytes or other interferences are present in the field environment.
- 3.11 Laboratory Control Sample (LCS) A blank spiked with the parameters of interest that is carried through the entire analytical procedure. Analysis of this sample with acceptable recoveries of the spiked materials demonstrates that the laboratory techniques for this method are acceptable.
- 3.12 Matrix Spike (MS) Aliquot of a matrix (water or solid) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.
- 3.13 Matrix Spike Duplicate (MSD) A second aliquot of the same sample as the matrix spike (above) that is spiked in order to determine the precision of the method.
- 3.14 Method Blank (MB) A quality control sample consisting of all reagents, internal standards and surrogate standards that is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background and reagent contamination.
- 3.15 Method Detection Limit (MDL) The MDL is defined as the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results.
- 3.16 Precursor Ion The precursor ion is the deprotonated molecule ([M-H]-) of the method analyte. In MS/MS, the precursor ion is the mass selected and fragmented by collisionally activated dissociation to produce distinctive product ions of smaller m/z.
- 3.17 Product Ion A product ion is one of the fragment ions produced in MS/MS by collisionally activated dissociation of the precursor ion.
- 3.18 Initial Calibration Verification (ICV) A solution of method analytes of known concentrations that is obtained from a source external to the laboratory and different from the source of calibration standards. The second source is used to fortify the ICV at a known concentration. The ICV is used to check calibration standard integrity.
- 3.19 Nonconformance Memo (NCM) A form used to document a nonconforming event. An analyst should document a nonconformance memo when a nonconforming event occurs. A nonconforming event may include the reporting of analytical data outside method or SOP criteria, or when there is a deviation from a written policy or procedure. Information in an NCM may be used by project managers to flag data in the report narrative, or by the quality department to track trends and initial corrective actions, where applicable. Additional information on the NCM policy and procedure is located in the nonconformance and corrective action SOP (ME001BO).

Shealy Environmental Services, Inc.

Page 6 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

3.20 The definitions of any additional terms used in this SOP can be found in the Shealy Quality Assurance Management Plan (QAMP).

4 INTERFERENCES

- 4.1 Non-volumetric glassware can be heated in a muffle furnace at 400 °C for 2 h or solvent rinsed. Volumetric glassware should be solvent rinsed and can be heated in an oven at a temperature below 120°C. Store clean glassware inverted or capped. Do not cover with aluminum foil since PFAAs may potentially be transferred from the aluminum foil to the glassware.
 - **NOTE:** PFAA standards, extracts and samples should not come in contact with any glass containers or pipettes as these analytes can potentially adsorb to glass surfaces. PFAA analyte, internal standard (IS) and surrogate standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in HDPE or polypropylene containers.
- 4.2 Method interferences may be caused by contaminants in solvents, reagents (including reagent water), sample containers and caps, and other sample processing equipment that lead to discrete artifacts and/or elevated baselines in the chromatograms. The method analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) products, LC solvent lines, methanol, aluminum foil, SPE sample transfer lines, etc. All items such as these must be routinely demonstrated to be free from interferences (less than 1/2 the LOQ for each method analyte) under the conditions of the analysis by analyzing method blanks as described in Section 9. Subtracting blank values from sample results is not permitted.
- 4.3 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending upon the nature of the water. Humic and/or fulvic material can be co-extracted during SPE and high levels can cause enhancement and/or suppression in the electrospray ionization source or low recoveries on the SPE sorbent.
- 4.4 SPE cartridges/tubes can be a source of interferences. The analysis of field and laboratory reagent blanks can provide important information regarding the presence or absence of such interferences. Brands and lots of SPE devices should be tested to ensure that contamination does not prevent analyte identification and quantitation.

5 SAFETY

- 5.1 Procedures shall be carried out in a manner that protects the health and safety of all Shealy associates.
- 5.2 As stated in the Shealy Comprehensive Chemical Hygiene, Safety, and Hazard Communication Plan (ME0012D), eye protection that satisfies ANSI Z87.1, laboratory coat, and at least latex gloves must be worn while samples, standards, and reagents are being handled. Disposable gloves that have been contaminated will be removed and discarded; other gloves will be cleaned immediately.
- 5.3 The health and safety hazards of many of the chemicals used in this procedure have not been fully defined. Additional health and safety information can be obtained from the Safety Data Sheets (SDS) maintained electronically in the public directory. The following specific hazards are known:

Shealy Environmental Services, Inc.

Page 7 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

5.3.1 The following chemical(s) is known to be **flammable**: Glacial acetic acid, methanol, isopropyl alcohol.

- 5.3.2 The following chemical(s) is known to be **corrosive**: Glacial acetic acid, ammonium hydroxide.
- 5.3.3 The following chemical(s) is known to present a **health hazard**: ammonium hydroxide.
- 5.4 Exposure to chemicals must be maintained as low as reasonably achievable; therefore, unless they are known to be non-hazardous, all samples should be opened, transferred, and prepared in a fume hood, or under other means of mechanical ventilation. Solvent and waste containers must be kept closed unless transfers are being made.
- 5.5 All work must be stopped in the event of a known or potential compromise to the health and safety of a Shealy associate. The situation must be reported immediately to the health and safety officer.
- 5.6 Primary standards should be purchased in solution. If neat materials must be obtained, they shall be handled in a fume hood.
- 5.7 PFOA has been described as carcinogenic to humans. Pure standard materials and stock standard solutions of these method analytes should be handled with suitable protection to skin and eyes as described in section 5.2. Materials must be handled inside of a fume hood to eliminate inhalation and ingestion hazards.

6 EQUIPMENT AND SUPPLIES

- 6.1 Due to the possibility of adsorption of analytes onto glass, HDPE containers are used for all standard, sample and extraction preparations. Any time a new lot of SPE cartridges/tubes, solvents, centrifuge tubes, microcentrifuge tubes, disposable pipets, or autosampler vials are used, it must be demonstrated that a MB is reasonably free of contamination and that the criteria in Section 9.6.1 are met.
- 6.2 Extract/Standard storage containers 15-mL, 8-mL, or 4-mL narrow-mouth HDPE container Thermo Scientific item# 2002-9050, 2002-9025, 2002-9125; 1.5-mL snap-cap polypropylene microcentrifuge tubes Fisher item# 05-408-129; or equivalent.
- 6.3 Centrifuge Tubes 15-mL conical polypropylene tubes with polypropylene screw caps for storing standard solutions and for collection of extracts (Falcon catalog #: 21008-931; MoldPro, Inc. item# MP-100, 17x100mm sample tubes, alternate extract collection tubes).
- 6.4 Autosampler Vials Polypropylene vials (Phenomenex part# AR0-9995-13) with polypropylene caps (Phenomenex part# AR0-89P6-13-C), or equivalent.
 - **NOTE:** Polypropylene vials and caps are necessary to prevent contamination of the sample from PTFE coated septa. However, polypropylene caps do not reseal, so evaporation occurs after injection. Thus, multiple injections from the same vial are not advisable.
- 6.5 Polypropylene Graduated Cylinders Suggested sizes include 25, 50, 100 and 1000-mL cylinders
- 6.6 Micropipettes Range of volumes (see section 7 for volumes needed)

Shealy Environmental Services, Inc. Document Number: ME00213-08

Page 8 of 69 Effective Date: 6/20/2018

- 6.7 Plastic Pipettes Polypropylene or polyethylene disposable pipettes, Fisher Cat# 13-711-7M or equivalent.
- 6.8 Analytical Balance Capable of weighing to the nearest 0.0001 g
- 6.9 Solid Phase Extraction (SPE) Apparatus
 - 6.9.1 SPE Cartridges 0.5 g, 6-mL SPE cartridges containing styrenedivinylbenzene (SDVB) sorbent phase; Strata-XL-AW 100um Polymeric Weak Anion (0.5 g, 6mL) (Phenomenex Part # 8B-S051-HCH) or equivalent
 - 6.9.2 Envi-Carb SPE tubes, 0.25g, 6mL, Supelco part# 57092, or equivalent.
 - 6.9.3 Vaccum Extraction Manifold 24-port SPE manifold, Phenomenex part# AH0-6024, or equivalent. Care must be taken with automated SPE systems to ensure the PTFE commonly used in these systems does not contribute to unacceptable analyte concentrations in the MB.
 - 6.9.4 SPE reservoirs 60mL polypropylene, Phenomenex part# AH0-7189, or equivalent.
 - 6.9.5 SPE adapter caps Phenomenex Part# AH0-7191 (Adapter cap for 1, 3, 6mL SPE tubes)
 - 6.9.6 Vacuum tubing 1/4" ID, 5/8" OD, 3/16" wall; Fisher Scientific part# 14-176-6B or equivalent
- 6.10 Vacuum Pump Sufficient capacity to maintain a vacuum of approximately 10 to 15 inches of mercury for extraction cartridges. Millipore model# WP6111560, 115V, 60Hz, 3.5A.
- 6.11 Liquid Chromatography (LC)/Tandem Mass Spectrometer (MS/MS) with Data System.
 - 6.11.1 LC System Agilent Model 1260, with Degasser (G4225A), Binary Pump (G1312B), Autosampler (G1329B), Column Compartment (G1316A).
 - **NOTE:** PFAAs can build up in the PTFE solvent transfer lines and PTFE solvent frits. To prevent long delays in purging high levels of PFAAs from the LC solvent lines, PEEK tubing and stainless steel frits are used.
 - 6.11.2 Tandem Mass Spectrometer (MS/MS) Sciex 4500 MS/MS, in negative ion electrospray ionization (ESI) mode. A minimum of 10 scans across the chromatographic peak is required to ensure adequate precision.
 - 6.11.3 Data System Sciex MultiQuant and Sciex Analyst.
 - 6.11.4 Analytical Column Phenomenex Gemini® 3μm C18 110Å LC column 50 x 2mm, (part# 00B-4439-B0). Any column that provides adequate resolution, peak shape, capacity, accuracy, and precision may be used.
 - 6.11.5 Mixing/Guard Column Phenomenex Luna 5µm C18 100Å LC column 30 x 3mm (part# 00A-4252-Y0) or equivalent.

Shealy Environmental Services, Inc. Document Number: ME00213-08

Page 9 of 69 Effective Date: 6/20/2018

- 6.11.6 Guard cartridge SecurityGuard Cartridges: Gemini C18, 2-3mm ID, 10/pk; Part# AJ0-7596; Phenomenex Part# KJ0-4282 (SecurityGuard Guard Cartridge Kit)
- 6.13 Vortex Mixer: Bibby Scientific/Stuart Vortex Mixer, Model SA8, or equivalent.
- 6.14 Orbital shaker table: VWR Model 3500 Standard Shaker, 120V, or equivalent
- 6.15 Centrifuge: VWR Clinical 200, or equivalent
- 6.16 Sonicator: VWR Model 97043-976, or equivalent
- 6.17 Ottawa sand for solid QC preparation (VWR catalog #: EM-SX0075-3 or equivalent)

7 REAGENTS AND STANDARDS

- 7.1 Reagent grade or better chemicals should be used. Unless otherwise indicated, it is intended that ACS reagents be used, where such specifications are available. Other grades may be used, provided it is first determined that the reagent is of sufficiently high purity to permit its use without lessening the quality of the analysis.
 - 7.1.1 Reagent Water Optima LC/MS water, Fisher part# W6-4 or equivalent.
 - 7.1.1.1 The reagent water should not contain any measurable quantities of any method analytes or interfering compounds greater than 1/2 the LOQ for each analyte of interest.
 - 7.1.2 Methanol (MeOH, CH₃OH, CAS#: 67-56-1) HPLC grade, demonstrated to be free of analytes and interferences (Fisher part# A452-4 or equivalent).
 - 7.1.3 Ammonium Acetate (NH₄C₂H₃O₂, CAS#: 631-61-8) LC/MS grade, demonstrated to be free of analytes and interferences (Fisher part# A114-50 or equivalent).
 - 7.1.4 20 mM Ammonium Acetate To prepare 1 L, add 1.54 g ammonium acetate to 1L of reagent water (0.77g into 0.5L reagent water). This solution is prone to volatility losses and should be replaced at least every 48 hours.
 - 7.1.5 Ammonia-Methanol (Amm-MeOH, 0.3%) In a 500 mL class A volumetric flask add 6.76 mL NH4OH (Ammonium Hydroxide) and fill to volume with reagent water (493.24 mL reagent MeOH). Invert to mix.
 - 7.1.6 Ammonium Acetate/Acetic Acid buffer (25mM, pH 4) In a class A 500 mL volumetric flask add 0.58 mL acetic acid and 0.20 g ammonium acetate then fill to volume with reagent water (499.42 mL reagent water). Invert to mix.
 - 7.1.7 Nitrogen Nitrogen aids in aerosol generation of the ESI liquid spray and is used as collision gas in some MS/MS instruments. The nitrogen used should meet or exceed instrument manufacturer's specifications.

Shealy Environmental Services, Inc. Document Number: ME00213-08 Page 10 of 69 Effective Date: 6/20/2018

7.2 Standard Solutions – When a compound purity is assayed to be 96% or greater (standards purchased from Wellington are >98%), the weight can be used without correction to calculate the concentration of the stock standard. PFAA analyte, IS, and SUR standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in HDPE containers. Solution concentrations listed in this section were used to develop this method and are included as an example. Alternate concentrations may be used as necessary depending on instrument sensitivity and the calibration range used. Standards for sample fortification generally should be prepared in the smallest volume that can be accurately measured to minimize the addition of excess organic solvent to aqueous samples.

NOTE: All standards are stored at 2-6°C.

- 7.2.1 Internal standards (IS) for Method 537-MOD ID are the following five compounds: Perfluoro-n-[1,2-13C2]hexanoic acid (13C2-PFHxA), Perfluoro-n-[1,2-13C2] octanoic acid (13C2-PFOA) and Sodium perfluoro-1-[1,2,3,4-13C4]octanesulfonate (13C4-PFOS), Perfluoro-n-[2,3,4-13C3] butanoic acid (13C3-PFBA) and Perfluoro-n-[1,2-13C2] decanoic acid (13C2-PFDA). The IS stocks are obtained from Wellington Labs (catalog # MPFHxA and catalog # MPFAC-C-IS). IS stock standard solutions are stable for 12 months when stored at 2-6°C.
 - 7.2.1.1 IS 50X Mix: Dilute the stock standard with methanol/water in accordance with section 7.3 and the table below:

537 MOD ID (Aqueous) IS 50X Mix

Standard Name	Conc. Of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.	
	μg/mĽ	μL	mL	μg/mL	
Perfluoro-n-[1,2-13C2]hexanoic acid (13C2-PFHxA)	50	200	10.0	1.0	

7.2.1.2 20 ppb IS Mix: Combine the IS 50X Mix in section 7.2.1.1 and Wellington Labs standard part# MPFAC-C-IS and dilute with methanol/water in accordance to section 7.3 and the table below:

537 MOD ID (Aqueous) 20 ppb IS Mix

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.	
	μg/mL	μL	mL	μg/mL	
IS Mix, 50X	1	200	10.0	0.020	
MPFAC-C-IS stock	2	100	10.0	0.020	

NOTE: The complete list of compounds included in the 537 MOD ID (Aqueous and Solid) 20 ppb IS Mix are found under Table 5.

7.2.2 Surrogate (SUR) Stock Standard Solutions – The SUR standard stocks are obtained from Wellington Labs (catalog #s: M2PFHxDA, M2-4:2FTS, M2-6:2FTS, M2-8:2FTS, M8FOSA-I, d-N-EtFOSA-M, d-N-MeFOSA-M, d5-N-EtFOSAA, d3-N-MeFOSAA-M and MPFAC-C-ES). SUR stock standard solutions are stable for 12 months when stored at 2-6°C.

Shealy Environmental Services, Inc. Document Number: ME00213-08

7.2.2.1 SUR 50X Mix: Dilute the stock standards with methanol/water in accordance with section 7.3 and the table below:

537 MOD ID (Aqueous) SUR 50X Mix

Standard Name	Conc. of	Aliquoted	Dilution	Final
	Stock Std.	Volume	Volume	Conc.
	μg/mL	μL	mL	μg/mL
Perfluoro-n-[1,2-13C2] hexadecanoic acid (13C2-PFHxDA)	50	200	10.0	1.0
Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] hexane sulfonate (M2-4:2FTS)	50	200	10.0	1.0
Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] octane sulfonate (M2-6:2FTS)	50	200	10.0	1.0
Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] decane sulfonate (M2-8:2FTS)	50	200	10.0	1.0
Perfluoro-1-[13C8] octanesulfonamide (13C8-PFOSA)	50	200	10.0	1.0
N-ethyl-d5-perfluoro-1-octanesulfonamide (d5-EtFOSA)	50	200	10.0	1.0
N-methyl-d3-perfluoro-1-octanesulfonamide (d3-MeFOSA)	50	200	10.0	1.0
N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid (d5-EtFOSAA)	50	200	10.0	1.0
N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid (d3-MeFOSAA)	50	200	10.0	1.0

7.2.2.2 20 ppb SUR mix: combine the SUR 50X mix in section 7.2.2.1 and Wellington Labs standard part# MPFAC-C-ES and dilute with methanol/water in accordance with section 7.3 and the table below:

537 MOD ID (Aqueous) 20 ppb SUR Mix

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.			
	μg/mL	μL	mL	μg/mL			
SUR mix, 50X	1	200	10.0	0.020			
MPFAC-C-ES stock	2	100	10.0	0.020			

7.2.2.3 100 ppb SUR mix: Combine the SUR PDS mix in section 1.4 and Wellington Labs standard part# MPFAC-C-ES and dilute with methanol/water in accordance with section 1.9 and the table below:

537 MOD ID (Solids) 100 ppb SUR Mix

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.
	μg/mL	μL	mL	μg/mL
PFAS 537 MOD ID SUR PDS mix, 50X	1	1000	10.0	0.10
MPFAC-C-ES stock	2	500	10.0	0.10

NOTE: The complete list of compounds included in the 537 MOD ID (Aqueous and Solid) 20 ppb SUR Mix are found under Table 5.

Shealy Environmental Services, Inc. Document Number: ME00213-08

7.2.3 Analyte Primary Dilution Standards – Analyte standards are purchased from Wellington Labs as ampoulized solutions. PFHxS, PFOS and other sulfonic acids are not available as the acid form, but rather as their corresponding salts, such as Na+ and K+. These salts are acceptable for use as stock standards as long as the weight is corrected for the salt content according to the equation below.

$$Mass_{acid} = Measured Mass_{salt} \times \frac{MW_{acid}}{MW_{salt}}$$

Where:

MW_{acid} = the molecular weight of PFAA MW_{salt} = the molecular weight of purchased salt

- 7.2.4 Analyte Primary Dilution Standard (PDS) Solutions For method 537-MOD ID (aqueous), a list of these solutions is provided below. The PDS standards are stable for two weeks when stored at room temperature, or 6 months when stored at 2-6°C. This expiry can be extended up to a total of 12 months if a verification of ICAL standards (made with these PDS solutions) versus the ICV gives 85 115% recovery for all analytes. Wellington Laboratories item #s for the standards used to prepare the PDS solutions are as follows: PFAC-24PAR (24 compound mix of native PFAS); N-MeFOSA-M; N-EtFOSA-M; 10:2FTS; HFPO-DA (GenX)
 - 7.2.4.1 Stock (10X) Analyte PDS (containing all target analytes at 0.2 ug/mL, GenX at 0.4 μ g/mL) 1 mL of the primary lot of PFAC-24PAR standard mix, 40 uL of MeFOSA, EtFOSA, and 10:2 FTS primary standards, and 80 uL of GenX primary standard are diluted to 10 mL with 8.4 mL of methanol and 400 uL reagent water.
 - 7.2.4.2 100X Analyte PDS (containing all target analytes at 20 ng/mL, GenX at 40 ng/mL) 1 mL of Stock (10X) Analyte PDS is diluted to 10 mL with 9 mL of 96% MeOH
 - 7.2.4.3 1000X Analyte PDS (containing all target analytes at 2.0 ng/mL, GenX at 4.0 ng/mL) 1 mL of 100X Analyte PDS is diluted to 10 mL with 9 mL of 96% MeOH
- 7.2.5 Initial Calibration Standards (ICAL) Using the standards in sections 7.2.1.2, 7.2.2.2, 7.2.4 and according to the table below, prepare calibration standards at the following concentrations in pg/mL (ng/L): 50, 100, 200, 500, 1000, 2000, 5000, and 10000. The ICAL standards are stable for two weeks when stored at room temperature, or 6 months when stored at 2-6°C. This expiry can be extended up to a total of 12 months if a verification versus the ICV gives 85 115% recovery for all analytes. The final composition of the above solutions contains 96:4% (vol/vol) methanol: water. See Table 5 for a list of analytes and exact concentrations.

Shealy Environmental Services, Inc.

Page 13 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

537 MOD ID (Aqueous) ICAL Standard Preparation

PFAS Conc. (pg/mL)	SUR Conc. (pg/mL)	IS Conc. (pg/mL)	PFAS FL PDS 10X	PFAS FL PDS 100X	PFAS FL PDS 1000X	20 ppb SUR	20 ppb IS	Final Volume
			mL	mL	mL	mL	mL	mL
50	1000	1000	-	-	0.125	0.25	0.25	5.00
100	1000	1000	-	-	0.250	0.25	0.25	5.00
200	1000	1000	-	-	0.500	0.25	0.25	5.00
500	1000	1000	-	0.125	-	0.25	0.25	5.00
1000	1000	1000	-	0.250	-	0.25	0.25	5.00
2000	1000	1000	-	0.500	-	0.25	0.25	5.00
5000	1000	1000	0.125	-	-	0.25	0.25	5.00
10000	1000	1000	0.25	-	-	0.25	0.25	5.00

- 7.3 The final compositions for all the standards in section 7.2 contain 96:4% (v/v) methanol/water. The solutions are stored in HDPE containers.
- 7.4 Initial Calibration Verification (ICV) Prepare the ICV according to the sections and the table below.
 - 7.4.1 100X ICV Mix (second source standard containing required target analytes at 0.02 ug/mL or 20ppb) 100 uL of the secondary lot (different than the lot used to prepare the PDS solutions) of PFAC-24PAR standard mix and 20 uL of GenX secondary standard is diluted to 10 mL with 9.88 mL of methanol. The PFAC-24PAR standard includes all analytes listed in Table 5 except the following: MeFOSA, EtFOSA, and 10:2FTS.
 - 7.4.2 ICV Sample Solution (500ppt) combine the solutions in sections 7.2.1.2, 7.2.2.2 and 7.4.1 according to the table below. The final solvent composition of this solution should be 96:4% MeOH: water.

	537 MOD ID (Aqueous) ICV Preparation			
Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.
	pg/mL	μL	mL	pg/mL
PFAS ICV 100X Mix	20000	25	1.0	500
Full List SUR mix, 20ppb	20000	50	1.0	1000
Full List IS mix, 20ppb	20000	50	1.0	1000

- 7.5 Instrument Blank (IBLK) The instrument blank is prepared by spiking 180 μ L 96% MeOH with 10 μ L of 20 ppb IS Mix and 10 μ L of 20 ppb SUR Mix in an autosampler vial. Cap and vortex to mix.
- 7.10 Method Blank (MB) Spike 250 mL reagent water with 495 µL of the 20 ppb SUR Mix. Mix well, extract as normal alongside client samples.
- 7.11 Continuing Calibration Verification/Instrument Sensitivity Check (CCV/ISC) The CCV and the ISC are prepared in the same manner. The daily Instrument Sensitivity Check (ISC; DOD required) will be used as the daily opening CCV, and will be analyzed at both the 100ppt and 200ppt levels, using prepared ICAL standards. The prepared ICAL standard at the 1000ppt level will be used as the CCV to be analyzed

Shealy Environmental Services, Inc.

Page 14 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

every ten samples and at the conclusion of the analytical run, as closing CCV. Analyte concentrations must be within +/-30% of their true values.

- 7.12 Laboratory Control Sample (LCS) The LCS for 537 MOD ID is prepared by spiking 250 mL of reagent water with 250 µL of the 100X PDS mix (20 ppb) for a concentration of 20 ppt (505 ppt on column concentration; GenX at 40 ppt, on column concentration of 1011 ppt). The LCS is also spiked with 99 µL of Full List 100 ppb SUR mix and extracted as normal alongside client samples.
- 7.13 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Client samples are spiked in the same manner as the LCS. 250mL of sample is spiked with 250 μL of 100X PDS mix (20 ppb) plus 99 μL of Full List 100 ppb SUR mix and extracted as normal alongside other client samples.
- 7.14 Method Detection Limit (MDL) MDL sample preparation and analysis will be performed over three separate days. Each MDL sample will be extracted with an equal number of MB samples. The MDL is prepared by spiking 250 mL of reagent water with 25 μ L of 100X PDS mix (20ppb), for a concentration of 2 ppt (50.5 ppt on column), plus 99 μ L of Full List 20ppb SUR mix and extracted as normal. An equal number of MB (see section 7.10 above) will be extracted and analyzed with MDL samples.
- 7.15 Initial (and Continuing) Demonstration of Capability (IDOC/CDOC) The IDOC/CDOC is prepared by spiking 250mL of reagent water with 250 µL of 100X ICV mix (20ppb) plus 99 µL of Full List 100ppb SUR mix and extracted as normal. IDOC/CDOC sample final concentration equals 20ppt (505ppt on-column concentration; GenX at 100ppt, 2527ppt on-column concentration).

8 SAMPLE COLLECTION, PRESERVATION AND STORAGE

- 8.1 Sample Containers and preservatives -
 - 8.1.1 Method 537 MOD ID (aqueous): Aqueous samples must be collected in a 250mL HDPE bottle fitted with a polyethylene screw-cap.
 - 8.1.2 Method 537-MOD ID (solid): Solid samples must be collected in a 4 oz. HDPE bottle fitted with a polyethylene screw-cap.
- 8.2 Sample temperature must be confirmed to be at or below 6°C when the samples are received at the laboratory. Samples stored in the lab must be stored at 4 ± 2 °C.
- 8.3 Aqueous samples must be extracted within 14 days of collection and solid samples must be extracted within 28 days of collection. All sample extracts must be stored at room temperature and analyzed within 28 days after extraction.

9 QUALITY CONTROL

- 9.1 Initial Demonstration of Capability (IDOC) -
 - 9.1.1 For the standard analyte list, the initial demonstration and method detection limit (MDL) studies described in the Shealy QAMP must be acceptable before analysis of samples may begin.

Shealy Environmental Services, Inc.

Page 15 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

9.1.2 For non-standard, non-regulatory analytes, an MDL study should be performed and calibration curve generated before analyzing any samples, unless lesser requirements are previously agreed to with the client.

- 9.1.3 In any event, the minimum initial demonstration suggested is the analysis of an extracted standard at the reporting limit and a five point calibration curve.
- 9.2 Method Modifications The analyst is permitted to modify LC columns, LC conditions, internal standards or surrogate standards, and MS and MS/MS conditions. Each time such method modifications are made, the analyst must repeat the procedures of the IDOC. **Modifications to LC conditions should still produce conditions such that co-elution of the method analytes is minimized to reduce the probability of suppression/enhancement effects.**
- 9.3 Method Detection Limit (MDL) The MDL is defined as the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results. See section 7.14 for preparation and analysis procedures.
- 9.4 LOD/LOQ verification Refer to document ME001F1-01, "Limit of Detection (LOD) and Limit of Quantitation (LOQ) Determination and Verification," for procedures to determine and verify the LOD/LOQ concentrations.
- 9.5 Instrument Blank (IBLK) Two instrument blanks are analyzed immediately following the highest two ICAL standards analyzed and also on a daily basis prior to sample analysis, to check for carryover and instrument contamination. The concentration of each analyte must be ≤ 1/2 the LOQ. If the instrument blank does not pass this requirement after the highest ICAL standard, the calibration must be performed using a lower concentration for the highest standard until the acceptance criteria is met.
- 9.6 Method Blank (MB) One method blank (MB) must be processed with each extraction and/or analytical batch. If more than 20 samples are included in a batch, analyze an MB for every 20 samples. The MB is to contain all reagents specific to the method that is carried through the entire analytical procedure, including preparation and analysis.
 - 9.6.1 The MB must not contain any analyte of interest at or above 1/2 of the LOQ or project specific requirements. (Note: see appendices for state or program specific requirements). If the MB contains an analyte of interest at or above 1/2 of the LOQ, then the MB and associated samples must be reanalyzed. If the MB contamination is confirmed, the entire batch must be re-prepared and reanalyzed. Reanalysis or re-extraction is not required if the samples are not impacted. Samples are not impacted when:
 - 9.6.1.1 The MB detection is not present in the sample.
 - 9.6.1.2 The sample concentration is $\ge 10x$ the concentration of the detection in the MB.
 - 9.6.2 The MB must have acceptable surrogate recoveries. If surrogate recoveries are not acceptable, sample analysis should stop immediately. Corrective action should be taken. The MB should be reanalyzed if the analyst feels that the failure could be attributed to instrument problems. If the analyst feels that the failure is due to a poor extraction, entire batch must be sent for re-extraction.

Shealy Environmental Services, Inc.

Page 16 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

9.7 Laboratory Control Sample (LCS) – An LCS is required with each extraction batch (Sect. 3.4). The spiked concentration of the LCS will be at a mid-point concentration of the calibration curve. Results of the LCS analyses must be 70-150% of the true value. If the LCS results do not meet these criteria for method analytes, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch.

- 9.8 Internal Standards (IS) The analyst must monitor the peak areas of the IS(s) in all injections during each analysis day. The IS responses (peak areas) in any chromatographic run must not deviate by more than 50% from the area measured during initial analyte calibration or the daily CCV. If the IS areas in a chromatographic run do not meet these criteria, inject a second preparation of that extract prepared in a new capped autosampler vial. Loss due to evaporation has been observed when using polypropylene caps which can cause high IS response.
 - 9.8.1 If the reinjected aliquot produces an acceptable IS response, report the results for that aliquot.
 - 9.8.2 If the reinjected extract fails again, the analyst should check the calibration by reanalyzing the most recently acceptable ICAL standard. If the ICAL standard fails the criteria of Section 10.2.4, recalibration is needed. If the ICAL standard is acceptable, extraction of the sample may need to be repeated provided the sample is still within the holding time. Otherwise, report results obtained from the reinjected extract, but write an NCM as to the circumstances under which the results are reported. Alternatively, a new sample can be collected and re-analyzed.
- 9.9 Surrogates (SUR) The surrogate standard is fortified into all samples, MBs, LCSs, MSs, MSDs prior to extraction. It is also included in the ICAL standards.
 - 9.9.1 The surrogate recovery must be within the range of 50-150%. When the surrogate recovery from a sample, blank, or CCV is not within this range check the following: calculations to locate possible errors, standard solutions for degradation, contamination, and instrument performance. Correct the problem and reanalyze the extract.
 - 9.9.1.1 If the extract reanalysis meets the surrogate recovery acceptance criteria, report only the data for the reanalyzed extract.
 - 9.9.1.2 If the extract reanalysis fails the 50-150% acceptance criteria, the analyst should check the calibration by injecting the last ICAL standard that passed. If the ICAL standard fails the criteria of Section 10.2.4, recalibration is in order. If the ICAL standard is acceptable, extraction of the sample should be repeated provided the sample is still within the holding time. If the re-extracted sample also fails the recovery acceptance criteria, write an NCM describing that the results are suspect due to surrogate recovery. Alternatively, a new sample can be collected and re-analyzed.
- 9.10 Matrix Spike (MS) Analysis of an MS is required in each extraction batch, if provided by the client. Assessment of method precision can be accomplished by analysis of a duplicate collected in the field (Field Duplicate (FD), Sect. 9.11); however, infrequent occurrence of method analytes might hinder this assessment. If the occurrence of method analytes in the samples is infrequent, or if historical trends are unavailable, a matrix spike duplicate (MSD), must be prepared, extracted, and analyzed. Extraction batches that contain MSD will not require the extraction of an FD.

Page 17 of 69 Effective Date: 6/20/2018

Shealy Environmental Services, Inc. Document Number: ME00213-08

- 9.10.1 Within each extraction batch (Sect. 3.4), a minimum of one sample is spiked as an MS for every 20 samples analyzed, if provided by the client. The MS is prepared by spiking a sample with an appropriate amount of the Analyte PDS (Sect. 7.2.4). Spiking compounds and levels are the same as the LCS.
 - 9.10.1.1 Analyte recoveries may exhibit matrix effect. For matrix spike samples, recoveries should range between 70-150%. If the % recovery falls outside of the acceptable range, corrective action must occur. The initial corrective action will be to check all calculations. If the calculations are correct, check the recovery of that analyte in the LCS. If the recovery of the analyte in the LCS is within limits, then matrix interference has been demonstrated and the laboratory operation may proceed. Analytical reports will show qualifier flags in such cases.
 - 9.10.1.2 If the recovery for any analyte is outside the acceptance criteria for the matrix spike and the LCS, the laboratory is out of control and corrective action will be taken. Corrective action may include re-preparation and reanalysis of the batch. An NCM will be generated to document the corrective action taken.
- 9.11 Field Duplicate (FD) or Matrix Spike Duplicate (MSD) Within each extraction batch (not to exceed 20 Field Samples, Sect. 3.4), a minimum of one FD or MSD must be analyzed, if provided by the client. If method analytes are not routinely observed in field samples, an MSD should be analyzed rather than an FD.
 - 9.11.1 Relative Percent Differences (RPDs) FDs should have RPDs that are ≤30% between the original sample and the FD. If the RPD of any analyte falls outside the acceptance criteria, and the laboratory performance for that analyte is shown to be in control in the LCS, the recovery is judged to be matrix biased. An NCM is written describing that the result for that analyte in the unspiked sample is suspect due to matrix effects.
 - 9.11.2 RPDs for MS/MSDs should be ≤30%. If the RPD falls outside of the acceptable range, corrective action must occur. The initial corrective action will be to check all calculations. If the calculations are correct, check the recovery of that analyte in the LCS. If the recovery of the analyte in the LCS is within limits, then matrix interference has been demonstrated and the laboratory operation may proceed. Analytical reports will show qualifier flags in such cases.
 - 9.11.3 Every effort is made to ensure that an MS/MSD or an FD is included in every batch. In the event that there is insufficient sample to analyze an MS/MSD pair or if no FD is available, a duplicate LCS (laboratory control sample duplicate (LCSD)) is included in the batch. The MS/MSD must be analyzed at the same dilution as the most concentrated reportable analysis of the parent sample (the un-spiked sample).
- 9.12 Trip Blank (TB) The purpose of the TB is to ensure that PFAAs measured in the samples were not inadvertently introduced into the sample during sample collection/handling. Analysis of the TB is required only if a sample contains a method analyte or analytes at or above the LOQ. The TB is processed, extracted and analyzed in exactly the same manner as the samples. If an analyte found in the sample is present in the TB at a concentration greater than 1/2 the LOQ, then all samples collected with that TB are invalid and must be recollected and reanalyzed.

10 CALIBRATION AND STANDARDIZATION

- 10.1 Demonstration and documentation of acceptable initial calibration is required before any samples are analyzed. After the initial calibration is successful, a CCV is required at the beginning and end of each period in which analyses are performed, and after every tenth Field Sample.
- 10.2 Initial Calibration (ICAL)
 - 10.2.1 ESI-MS/MS Tune: Calibrate the mass scale of the MS with the calibration compounds and procedures prescribed by the manufacturer. Mass calibration/mass tune will be performed any time major maintenance is performed on the MS, or following any catastrophic instrument failure (power loss, etc.)
 - 10.2.2 Prepare a set of at least five ICAL standards as described in Section 7.2.5. The lowest concentration ICAL standard must be at or below the LOQ, which may depend on system sensitivity. It is recommended that at least four of the ICAL standards are at a concentration greater than or equal to the LOQ.
 - 10.2.3 The LC/MS/MS system is calibrated using the IS technique. Generate a linear regression calibration curve for each of the analytes. This curve will typically be forced through zero and may be concentration weighted, if necessary. Forcing through zero allows for a better estimate of the background levels of method analytes.
 - 10.2.3.1 The isotopically labeled IS(s)/SUR(s) in this method may undergo suppression in the ESI source if the concentration of the co-eluting unlabeled method analyte(s) is too high. The analyte concentration at which suppression may occur can vary depending on the instrument, LC conditions, ESI conditions, IS/SUR concentration, etc. To evaluate whether suppression is occurring during calibration, calculate the relative percent difference (RPD) between the high (H) and low (L) areas for each IS/SUR using the equation:

$$RPD = \frac{(H - L)}{(H + L)} \times 100$$

Where: H = high area L = low area

- 10.2.3.2 The RPD calculated above must be <20% for each IS/SUR during calibration. If the calculated RPD is >20% for any IS/SUR, the analyst must recalibrate at lower analyte concentrations until the IS/SUR RPDs are <20%. Use document ME002HQ-01, "PFAS IS-SUR suppression check" to calculate and record the RPD for all IS and SUR compounds.
- 10.2.3.3 The linear regression curve is expressed as below:

$$y = ax + b$$

Where a is the slope and b is the y-intercept. When forced through 0, b=0.

$$y = A_S/A_{SUR} \hspace{1cm} x = C_S/C_{SUR} \label{eq:surface}$$

Shealy Environmental Services, Inc.

Page 19 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

 A_S is peak response of target analyte in calibration standards A_{SUR} is peak response of surrogate standard (SUR) in calibration standards C_S is concentration of target analyte in calibration standards C_{SUR} is concentration of surrogate standard (SUR) in calibration standards

10.2.4 Calibration Acceptance Criteria – When quantitated using the ICAL curve, each calibration level for each analyte should calculate to be within 70-130% of its true value. For calibration curves produced using average response factors, the percent relative standard deviation (%RSD) of the RFs for all analytes must be <20%. Linear or non-linear calibrations must have $r^2 \ge 0.99$ ($r \ge 0.995$) for each analyte. If these criteria cannot be met, the analyst will have difficulty meeting ongoing QC criteria. It is recommended that corrective action is taken to reanalyze the ICAL standards, restrict the range of calibration, or select an alternate method of calibration (forcing the curve through zero is still recommended).

NOTE: When acquiring MS/MS data, LC operating conditions must be carefully reproduced for each analysis to provide reproducible retention times. If this is not done, the correct ions will not be monitored at the appropriate times. As a precautionary measure, the chromatographic peaks in each window must not elute too close to the edge of the segment time window.

- 10.3 Initial Calibration Verification (ICV) As part of the IDOC (Sect. 9.1), each time a new Analyte PDS (Sect. 7.2.4) is prepared, and once after each ICAL, analyze an ICV sample from a second source (different from the source of the ICAL standards). If a second vendor is not available, then a different lot of the standard should be used. The ICV should be prepared and analyzed just like a CCV. Acceptance criteria for the ICV are identical to the CCVs; the calculated amount for each analyte must be ± 30% of the expected value. If measured analyte concentrations are not of acceptable accuracy, correct the problem and rerun the ICV. If the problem persists, repeat the ICAL. Samples are not to be analyzed until the ICAL has been verified by acceptable ICV accuracy.
- 10.4 Continuing Calibration Verification (CCV) CCV Standards are analyzed at the beginning of each analysis batch, after every 10 samples, and at the end of the analysis batch. In this context, a "sample" is considered to be a field sample. MBs, CCVs, LCSs, MSs, FDs, TBs and MSDs are not counted as samples. The beginning CCV of each analysis batch (Instrument Sensitivity Check ISC) must be at or below the LOQ in order to verify instrument sensitivity prior to any sample analysis. If standards have been prepared such that all low ICAL points are not in the same ICAL solution, it may be necessary to analyze two ICAL standards to meet this requirement. Alternatively, the analyte concentrations in the analyte PDS may be customized to meet this criteria. The prepared ICAL solution at 1000ppt will be analyzed for subsequent and closing CCVs.
 - 10.4.1 Inject an aliquot of the appropriate concentration ICAL standard and analyze with the same conditions used during the initial calibration.
 - 10.4.2 Determine that the absolute areas of the quantitation ions of the IS(s) are within 50-150% of the areas measured in the most recent CCV, or, if ICAL was performed the same day, IS areas must be within 50-150% of the midpoint of the ICAL range (1000ppt). If any of the IS areas has changed by more than these amounts, adjustments must be made to restore system sensitivity. These adjustments may include cleaning of the MS ion source, or other maintenance. Major instrument maintenance requires recalibration and verification of sensitivity by analyzing a CCV at or below the LOQ (Sect 9.4). Control charts are useful aids in documenting system sensitivity changes.

Shealy Environmental Services, Inc.

Page 20 of 69
Document Number: ME00213-08

Effective Date: 6/20/2018

10.4.3 Calculate the concentration of each analyte and surrogate in the CCV. The calculated amount for each analyte must be within ±30% of the true value. The calculated amount for each surrogate compound must be within ±50%. If these conditions do not exist, then all data for the problem analyte must be considered invalid, and remedial action should be taken which may require recalibration. Any field or QC samples that have been analyzed since the last acceptable calibration verification should be reanalyzed after adequate calibration has been restored, with the following exception: if the CCV fails because the calculated concentration is greater than 130% for a particular method analyte, and the field sample extracts show no detection for that method analyte, non-detects may be reported without re-analysis.

- 10.4.4 Remedial Action Failure to meet CCV QC performance criteria may require remedial action. Major maintenance, such as cleaning the electrospray probe, atmospheric pressure ionization source, cleaning the mass analyzer, replacing the LC column, etc., requires recalibration (Sect 10.2) and verification of sensitivity by analyzing a CCV at or below the LOQ (Sect 9.4).
- 10.4.5 If reanalysis cannot be performed, the data must be qualified. An NCM must be generated which describes the reason that reanalysis is not being performed.
- 10.5 Correction Factors Correction Factors (CF) will be used to calculate original sample concentration. The CF is the inverse of the concentration factor (sample volume / extract final volume) times the dilution factor (DF). For undiluted analysis, the extract is prepared for injection by adding 182 μ L of sample extract, 8 μ L of reagent water, and 10 μ L of 20ppb IS mix to a polypropylene autosampler vial. An extract correction factor of 0.91 (182 μ L / 200 μ L = 0.91) applies. The CF is calculated as follows:

 $CF = DF \times FV / V_0$

Where:

FV is the volume of extract (mL)

 V_0 is the initial sample volume (mL)

DF is the dilution factor. For undiluted analysis, DF = 1/0.91

11 PROCEDURE

11.1 Some of the PFAAs adsorb to surfaces, including polypropylene and HDPE. Therefore, aqueous sample containers must be rinsed with the elution solvent. The container rinse is passed through the cartridge to elute the method analytes and is then collected.

NOTE: The SPE cartridges, reservoirs, and sample containers described in this section are designed as single use items and should be discarded after use. They may not be refurbished for reuse in subsequent analyses.

- 11.2 Sample Preparation (aqueous)
 - 11.2.1 Spike the sample containers with 99 μ L of the 100 ppb SUR Mix, shake/invert the sample to mix.
 - 11.2.2 Spike the MB, LCS, MS, and either FD or MSD appropriately according to the corresponding section under Reagents and Standards (Section 7)

Shealy Environmental Services, Inc.

Page 21 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

11.2.3 Attach the SPE extraction cartridges (Strata-XL-AW) to the converter caps and the reservoirs. Place the cartridge setups in the active SPE manifold ports.

- 11.2.4 Wet the rim of the manifold body with DI water to form a proper seal with the manifold top.
- 11.2.5 Place the top on the SPE manifold, start the vacuum pump, and ensure the vacuum is approximately 5in. Hg.
- 11.2.6 Condition each SPE cartridge with the following (do not allow to go dry during conditioning):
 - o 4mL Ammonia-MeOH (0.3%)
 - o 4mL MeOH
 - 4mL Ammonium acetate/acetic acid buffer
 If the SPE cartridge goes dry during any step of the conditioning process, restart conditioning with first step (Amm-MeOH)
- 11.2.7 Weigh the full sample container.
- 11.2.8 Add the entire water sample to the SPE tube/reservoir (do not allow to go dry during sample loading).
- 11.2.9 Adjust the pressure/SPE port settings to pass the sample at ~10-15mL/min.
- 11.2.10 Weigh the empty container and document the weight.
- 11.2.11 The difference between the weights from sections 11.2.7 and 11.2.10 is the sample volume (assuming 1g/mL density).
- 11.2.12 Once entire sample has passed through the SPE cartridge, wash the cartridge with 4 mL of the Ammonium Acetate/acetic acid buffer.
- 11.2.13 Use the vacuum to dry cartridges under high vacuum (approx. 10-20in. Hg) for ~5mins.
- 11.2.14 Release the vacuum, remove the top from the SPE manifold and place the eluent collection tubes in the manifold. Wet the rim of the manifold and replace the top, ensuring that the active SPE ports are set in the corresponding collection tubes and a proper seal is formed. Turn the pump back on and ensure the pressure is approximately 5in. Hg.
- 11.2.15 Rinse each empty sample container with 4mL MeOH. Transfer to the SPE, using a pipette to swirl MeOH along the sides of the reservoir to rinse.
- 11.2.16 Rinse each empty sample container a second time with 4mL Ammonia-MeOH (0.3%). Transfer to the SPE, using a pipette to swirl the Ammonia-MeOH solution along the side of the reservoir to rinse.

Shealy Environmental Services, Inc.

Page 22 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

11.2.17 Collect the total eluent in collection tubes. Adjust the pressure/SPE port settings to elute in a dropwise fashion.

- 11.2.18 Release the vacuum and remove the collection tube rack.
- 11.2.19 Replace the extraction cartridge setups (Strata-XL-AW and reservoirs) with Envi-Carb cleanup SPE tubes; place the manifold top on the manifold body and resume the vacuum, ensuring a proper seal and pressure.
- 11.2.20 Condition the Envi-Carb SPE tubes with 3 mL MeOH, but do not dry the tubes fully. **If the SPE** cartridge goes dry during the conditioning process, restart conditioning.
- 11.2.21 Release the vacuum, remove the top, and place the collection rack with clean, empty collection tubes in the manifold body, ensuring the proper alignment of the SPE ports with collection tubes. Resume the vacuum, ensuring a proper seal and pressure. Filter the extract through the Envi-Carb SPE tubes under vacuum and collect the eluent.
- 11.2.22 Rinse the Envi-Carb tubes with 1mL of fresh MeOH and collect the eluent.
- 11.2.23 In a polypropylene autosampler vial, combine 8 μ L water, 10 μ L (20ppb) IS mix, and 182 μ L of sample extract. Cap and vortex to mix. This aliquot is ready for analysis.
- 11.2.24 Transfer the remaining extracts to 8 mL HDPE containers for storage at room temperature.
- 11.2.25 Manifold cleanup use the methanol squirt bottle to thoroughly rinse all stopcocks on the vacuum manifold top. The stopcocks should be rotated while methanol is squirted into/through the stopcocks so that the entire body of the stopcock housing and rotor are cleaned well. The rotor should be rotated several times in both directions to ensure the stopcock is thoroughly decontaminated.
- 11.2.26 Correction Factors Correction Factors (CF) will be used to calculate original sample concentration.

The CF is the inverse of the concentration factor (sample volume / extract final volume) times the dilution factor (DF). For undiluted analysis, the extract is prepared for injection by adding 182 μ L of sample extract, 8 μ L of reagent water, and 10 μ L of 20ppb IS mix to a polypropylene autosampler vial. An extrac correction factor of 0.91 (182 μ L / 200 μ L = 0.91) applies. The CF is calculated as follows:

$$CF = DF \times FV / V_o$$

Where:

FV is the volume of extract (mL)

V_o is the initial sample volume (mL)

DF is the dilution factor. For undiluted analysis, DF = 1/0.91

11.2.27 For samples that show analyte detections above the range of the ICAL, sample dilutions will need to be prepared. See Appendix D for dilution preparation scheme.

Page 23 of 69 Effective Date: 6/20/2018

Shealy Environmental Services, Inc. Document Number: ME00213-08

11.3 Analytical Procedure

- 11.3.1 Column Flush Each day of analysis, the column must be thoroughly flushed with 100% MeOH for approximately 20 minutes to clear any accumulated impurities and interferents from the sample pathway. It is also good practice to open the purge valve on the pumps for the first ~1min of flush time. The column should then be equilibrated to the analysis starting conditions by flushing for ~10mins with 50:50 Ammonium Acetate: MeOH and finally ~10mins with 95:5 Ammonium acetate: MeOH. Ensure that pressure is stable.
- 11.3.2 Analytical Sequence Following the daily column flush, three (3) blank injections will be made in order to prime the system before analyzing opening QC and client samples. Following these opening blanks, Instrument Sensitivity Check (ISC) samples will be analyzed as the opening CCV (Sec. 10.4). When a passing ISC sample has been evaluated, an instrument blank will be analyzed to demonstrate the absence of system contamination. After system contamination is determined to be acceptable (no target analyte concentrations >1/2 LOQ), samples may be analyzed. After every tenth field sample analyzed in a sequence, a CCV will be analyzed (Section 10.4), as well as at the end of the sequence.

11.3.3 Chromatographic Conditions

Step	Total Time (min)	Flow Rate (uL/min)	A: 20mM Ammonium Acetate (%)	B: Methanol (%)
0	0.00	600	95.0	5.0
1	0.10	600	45.0	55.0
2	4.50	600	1.0	99.0
3	8.00	600	1.0	99.0
4	8.50	600	95.0	5.0
5	11.00	600	95.0	5.0

11.3.4 Mass Spectrometric Conditions

Parameter	Setting or Value
Syringe Size	100 μL
Injection Volume	10 μL
Draw Speed	50.0 μL/min
Eject Speed	50.0 μL/min
Needle Level	3.0 mm
Column Oven Temperature	40°C
MRM Scan Window	60 sec
Curtain Gas (CUR)	30.0
Collision Gas (CAD)	9
Ion Spray Voltage (IS)	-4500.0 V
Temperature (TEM)	450.0°C
Ion Source Gas 1 (GS1)	40.0
Ion Source Gas 2 (GS2)	60.0

Shealy Environmental Services, Inc. Document Number: ME00213-08

Page 24 of 69 Effective Date: 6/20/2018

12 DATA ANALYSIS AND CALCULATION

NOTE: The surrogate (SUR) standard is used for quantitation in the 537-MOD ID methods.

- 12.1 Complete chromatographic resolution is not necessary for accurate and precise measurements of analyte concentrations using MS/MS. Concentrations are calculated by measuring the product ions (Q3 Mass) listed in Table 4. Other ions may be selected at the discretion of the analyst.
- 12.2 Calculate analyte and surrogate concentrations using the multipoint calibration established in Section 10.2. Do not use daily calibration verification data to quantitate analytes in samples. Using the calculated CF (Sec. 11.2.25) adjust final analyte concentrations to reflect the actual sample volume determined in Section 11.
 - 12.2.1 Sample concentration for aqueous samples:

Concentration (ng/L) = (Cs)(DF)

Where:

DF = dilution factor Cs – see section 12.2.3

12.2.3 From the equation in section 10.2.3.3, Cs is calculated as follows:

$$Cs = \left(\frac{As}{Asur} - b\right) \cdot \left(\frac{Csur}{a}\right)$$

Where:

A_s is peak response of target analyte in the sample

A_{sur} is peak response of internal standard in the sample (SUR for isotope dilution methods)

C_s is concentration of target analyte in the sample

C_{sur} is concentration of internal standard in the sample (SUR for isotope dilution methods)

a is the slope from the ICAL linear regression

b is the y-intercept from the ICAL linear regression

- 12.3 Prior to reporting the data, the chromatogram should be reviewed for any incorrect peak identification or poor integration.
- 12.4 Dilution When the concentrations of target analytes on-column exceed the highest concentration of initial calibration standard, dilution analyses are required. An appropriate dilution should be in the upper half of the calibration range, or close to the CCV. The diluted extract must maintain the same methanol/water ratio as the original extract. If a dilution of the extract is required, fortification of the diluted extract is necessary. Refer to Appendix D for dilution preparation information.
- 12.5 PFHxS and PFOS have multiple chromatographic peaks using the LC conditions in Table 4 due to the linear and branched isomers of these compounds. The areas of all the linear and branched isomer peaks observed in the ICAL standards for each of these analytes must be integrated together and summed. The concentrations are reported as a total for each of these analytes. Purchased standards contain both linear and branched isomers; therefore, individual ICALs for the linear and branched isomers will not be possible. PFOA also has multiple chromatographic peaks using the LC conditions in Table 4 due to

linear and branched isomers of this compound. However, a quantitative standard containing both linear and branched isomers is not currently available, so ICAL standards will not show multiple peaks for PFOA. A technical (qualitative) standard is analyzed with each calibration event to identify where the branched isomer peak elutes, relative to the linear isomer peak. In client samples, the areas of the linear and branched isomer peaks observed must be integrated together and summed. The concentration of PFOA in client samples will be reported as a sum total of branched and linear isomers. As more standards (quantitative or qualitative) containing both branched and linear isomers for other target analytes become available, these will be used in the same way as for PFHxS/PFOS or PFOA. Following the same procedure, any target analyte for which a standard has been purchased and analyzed will be integrated and reported as a sum total of branched and linear isomers.

- 12.6 Integration Sample integration is performed automatically by quantitation software and reviewed by the analyst for any incorrect analyte identification or poor integration. A peak is considered a positive detection if the primary (quantitation) ion transition peak shows a signal-to-noise ratio (S/N) of at least 10:1 and is defined by at least 10 MS scans (data points) across the baseline of the peak. For analytes with a secondary (confirmation) ion transition, the primary and secondary ion transitions must elute at nominally the same retention time. Further, the secondary transition must show a S/N of at least 3:1.
- 12.7 Calculations must utilize all available digits of precision, but final reported concentrations should be rounded to an appropriate number of significant figures (one digit of uncertainty), typically two, and not more than three significant figures.
- 12.8 Calculate the % recovery for the SUR and LCS using the following equation:

% Recovery =
$$\frac{\text{Concentration (or amount) found}}{\text{Concentration (or amount) spiked}} \times 100$$

12.9 Calculate the MS % recovery for each analyte using the equation:

% Recovery =
$$\frac{Xs}{t}$$
 × 100

Where:

 X_s = measured concentration in the spiked sample X = measured concentration in the unspiked sample t = spike concentration

12.10 Calculate the relative percent difference (RPD) for duplicate measurements (FD1 and FD2 or MS and MSD) using the equation:

RPD =
$$\frac{|X1 - X2|}{(X1 + X2)} \times 100$$

Where:

X1 = FD1 or MS result X2 = FD2 or MSD result

Shealy Environmental Services, Inc.

Page 26 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

12.11 Calculate the percent relative standard deviation (%RSD) for calibration curves produced using average response factor using the equation:

$$\% RSD = \frac{SD}{AVG} \times 100$$

Where:

SD = the standard deviation of the curve

AVG = the average response factor for the curve (y = AVG*x)

13 METHOD PERFORMANCE

- 13.1 Method Detection Limit (MDL) The laboratory must generate a valid method detection limit for each analyte of interest on an annual basis or when there has been a major system change. These changes would include new instrumentation, change in prep volume, or injection volume. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in the Shealy QAMP.
- 13.2 Initial Demonstration of Capability (IDOC) Each analyst must make an initial demonstration of capability for each individual method. An IDOC for both solid and water matrices is required. This requires analysis of the LCS containing a representative list of analytes for the method.
 - 13.2.1 Four aliquots of the LCS are analyzed using the same procedures used to analyze samples, including sample preparation. The concentration of the LCS sample should be in the middle of the ICAL range.
 - 13.2.1.1 The analysis of a MB must pass the criteria in Section 9.6.
 - 13.2.1.2 Calculate the average recovery and standard deviation of the recovery for each analyte of interest. Compare these results with the acceptance criteria given below.
 - 13.2.1.3 The relative standard deviation (RSD) of the results of the replicate analyses must be less than 20%.
 - 13.2.1.4 The average recovery of the replicate values must be within \pm 30% of the true value.
 - 13.2.2 If any analyte does not meet the acceptance criteria, the test must be repeated. Only those analytes that did not meet criteria in the first test need to be evaluated. Repeated failure for any analyte indicates the need for the laboratory to evaluate the analytical procedure and take corrective action.
 - 13.2.3 An IDOC must be performed for any new analyst being trained to perform the method. The IDOC demonstrates that the analyst can perform the method, or portion of the method they are responsible for. An IDOC must also be performed if there is any major change in preparation procedure, such as change in solvent. A continuing demonstration of capability (CDOC) must be performed annually. The CDOC is established either by the procedure in section 13.2 or via participation in a passing proficiency test (PT).
 - 13.2.4 A continuing demonstration of capability (CDOC) is required annually.

Shealy Environmental Services, Inc. Document Number: ME00213-08

Page 27 of 69 Effective Date: 6/20/2018

13.3 Training Qualification – The department group leader has the responsibility to ensure that this procedure is performed by an analyst who has been properly trained in its use and has the required experience.

14 POLLUTION PREVENTION

14.1 This method utilizes SPE to extract analytes from water. It requires the use of very small volumes of organic solvent and very small quantities of pure analytes, thereby minimizing the potential hazards to both the analyst and the environment as compared to the use of large volumes of organic solvents in conventional liquid-liquid extractions.

15 WASTE MANAGEMENT

15.1 Waste generated in this procedure must be segregated and disposed according to the *Shealy Hazardous* and *Non-Hazardous Laboratory Waste Management Plan* [HS SOP ME0012A]. The Waste Manager should be contacted if additional information is required.

16 REFERENCES

- 16.1 Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography / Tandem Mass Spectrometry (LC/MS/MS), USEPA, Method 537, Revision 1.1, September 2009.
- 16.2 Department of Defense Department of Energy Quality Systems Manual (QSM) for Environmental Laboratories, Final Version 5.1.1, Table B-15, 2018.
- 16.3 Water Quality Determination of Perluorooctanesulfonate (PFOS) and Perfluorooctanoate (PFOA) Method for Unfiltered Samples Using Solid Phase Extraction and Liquid Chromatography/Mass Spectrometry, ISO 25101:2009(E).
- 16.4 Solvent-Extractable Nonvolatile Compounds by High-Performance Liquid Chromatography /Thermospray/Mass Spectrometry (HPLC/TS/MS) or Ultraviolet (UV) detection, USEPA, SW846, Method 8321B, Revision 2, February 2007.
- 16.5 Knepper, T.P. (2003) Analysis and Fate of Surfactants in the Aquatic Environment. Amsterdam, The Netherlands: Elsevier Science B.V.
- 16.6 Knepper, T.P. (2012) Polyfluorinated Chemicals and Transformation Products. Berlin, Germany: Springer-Verlag Berlin Heidelberg.
- 16.7 Rapid Commun Mass Spectrom. 2007;21 (23):3803-14.
- 16.8 ME0012K Shealy Quality Assurance Management Plan.

APPENDIX A: TABLES

TABLE 1: Target Analytes

	IADLE	1: 1 arget An	arytes	525 MOD	525	F2F
Analyte Name	Analyte Acronym	CAS Number	Method 537	537-MOD ID (Aqueous)	537 MOD DAI	537 MOD ID (Solids)
Fluorotelomer sulfonate 4:2 [1H,1H,2H,2H-perfluorohexane sulfonate]	4:2 FTS	757124-72-4*	No	Yes	No	Yes
Fluorotelomer sulfonate 6:2 [1H,1H,2H,2H-perfluorooctane sulfonate]	6:2 FTS	27619-97-2	No	Yes	No	Yes
Fluorotelomer sulfonate 8:2 [1H,1H,2H,2H-perfluorodecane sulfonate]	8:2 FTS	39108-34-4	No	Yes	No	Yes
1H,1H,2H,2H-perfluorododecane sulfonate	10:2FTS	120226-60-0*	No	Yes	No	Yes
N-ethylperfluoro-1- octanesulfonamidoacetic acid	EtFOSAA	2991-50-6	Yes	Yes	No	Yes
N-methylperfluoro-1- octanesulfonamidoacetic acid	MeFOSAA	2355-31-9	Yes	Yes	No	Yes
Perfluoro-1-butanesulfonate	PFBS	375-73-5	Yes	Yes	Yes	Yes
Perfluoro-n-butanoic acid	PFBA	375-22-4	No	Yes	Yes	Yes
Perfluoro-1-decanesulfonate	PFDS	2806-15-7	No	Yes	No	Yes
Perfluoro-n-decanoic acid	PFDA	335-76-2	Yes	Yes	Yes	Yes
Perfluoro-n-dodecanoic acid	PFDoA	307-55-1	Yes	Yes	No	Yes
Perfluoro-1-heptanesulfonate	PFHpS	375-92-8	Yes	Yes	No	Yes
Perfluoro-n-heptanoic acid	PFHpA	375-85-9	Yes	Yes	Yes	Yes
Perfluoro-1-hexanesulfonate	PFHxS	355-46-4	Yes	Yes	Yes	Yes
Perfluoro-n-hexanoic acid	PFHxA	307-24-4	Yes	Yes	Yes	Yes
Perfluoro-1-nonanesulfonate	PFNS	98789-57-2	Yes	Yes	No	Yes
Perfluoro-n-nonanoic acid	PFNA	375-95-1	Yes	Yes	Yes	Yes
Perfluorooctanesulfonate	PFOS	1763-23-1	Yes	Yes	Yes	Yes
Perfluoro-1-octanesulfonamide	PFOSA	754-91-6	No	Yes	No	Yes
Perfluoro-n-octanoic acid	PFOA	335-67-1	Yes	Yes	Yes	Yes
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3	Yes	Yes	Yes	Yes
Perfluoro-1-pentansulfonate	PFPeS	2706-91-4	Yes	Yes	No	Yes
Perfluoro-n-tetradecanoic acid	PFTeDA	376-06-7	Yes	Yes	No	Yes
Perfluoro-n-tridecanoic acid	PFTrDA	72629-94-8	Yes	Yes	No	Yes
Perfluoro-n-undecanoic acid	PFUdA	2058-94-8	Yes	Yes	No	Yes
N-methylperfluoro-1-octanesulfonamide	MeFOSA	31506-32-8	No	Yes	No	Yes
N-methylperfluoro-1-octanesulfonamide	EtFOSA	4151-50-2	No	Yes	No	Yes
Tetrafluoro-2-(heptafluoropropoxy) propanoic acid	GenX	13252-13-6	No	Yes	No	Yes

^{*} CAS Numbers are for the acid and not the salt.

Page 29 of 69 Effective Date: 6/20/2018

NOTE: Methods 537 and 537 MOD-DAI are addressed in SOPs ME002I6 and ME002I7 respectively.

Shealy Environmental Services, Inc. Document Number: ME00213-08

TABLE 2-A: Reporting Limits (LOQ) – EPA 537-MOD Isotope Dilution (Aqueous)

Analyte Acronym	Analyte Name	CAS Number	Spiked Conc ¹ (ng/L)	DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
EtFOSAA	N-ethylperfluoro-1- octanesulfonamidoacetic acid	2991-50-6	2.0	2	4	8
8:2 FTS	Fluorotelomer sulfonate 8:2 [1H,1H,2H,2H-perfluorodecane sulfonate]	39108-34-4	1.92	2	4	8
4:2 FTS	Fluorotelomer sulfonate 4:2 [1H,1H,2H,2H-perfluorohexane sulfonate]	757124-72-42	1.87	2	4	8
6:2 FTS	Fluorotelomer sulfonate 6:2 [1H,1H,2H,2H-perfluorooctane sulfonate]	27619-97-2	1.90	2.	4	8
MeFOSAA	N-methylperfluoro-1- octanesulfonamidoacetic acid	2355-31-9	2.0	2	4	8
PFBS	Perfluoro-1-butanesulfonate	375-73-5	1.77	1	2	4
PFBA	Perfluoro-n-butanoic acid	375-22-4	2.0	1	2	4
PFDS	Perfluoro-1-decanesulfonate	2806-15-7	1.93	1	2	4
PFDA	Perfluoro-n-decanoic acid	335-76-2	2.0	1	2	4
PFDoA	Perfluoro-n-dodecanoic acid	307-55-1	2.0	1	2	4
PFHpS	Perfluoro-1-heptanesulfonate	375-92-8	1.90	1	2	4
PFHpA	Perfluoro-n-heptanoic acid	375-85-9	2.0	1	2	4
PFHxS	Perfluoro-1-hexanesulfonate	355-46-4	1.82	1	2	4
PFHxA	Perfluoro-n-hexanoic acid	307-24-4	2.0	1	2	4
PFNS	Perfluoro-1-nonanesulfonate	98789-57-2	1.92	2	4	8
PFNA	Perfluoro-n-nonanoic acid	375-95-1	2.0	1	2	4
PFOS	Perfluorooctanesulfonate	1763-23-1	1.86	1	2	4
PFOSA	Perfluoro-1-octanesulfonamide	754-91-6	2.0	2	4	8
PFOA	Perfluoro-n-octanoic acid	335-67-1	2.0	1	2	4
PFPeA	Perfluoro-n-pentanoic acid	2706-90-3	2.0	1	2	4
PFPeS	Perfluoro-1-pentansulfonate	2706-91-4	1.88	1	2	4
PFTeDA	Perfluoro-n-tetradecanoic acid	376-06-7	2.0	2	4	8
PFTrDA	Perfluoro-n-tridecanoic acid	72629-94-8	2.0	1	2	4
PFUdA	Perfluoro-n-undecanoic acid	2058-94-8	2.0	1	2	4
MeFOSA	N-methylperfluoro-1-octanesulfonamide	31506-32-8	2.0	4	8	16
EtFOSA	N-methylperfluoro-1- octanesulfonamide	4151-50-2	2.0	2	4	8
10:2FTS	1H,1H,2H,2H-perfluorododecane sulfonate	120226-60-02	1.93	2	4	8
GenX	Tetrafluoro-2-(heptafluoropropoxy) propanoic acid	13252-13-6	4.0	1	2	8

¹Spiking concentration used to determine DL.

²CAS Numbers are for the acid and not the salt.

Page 30 of 69 Effective Date: 6/20/2018

Shealy Environmental Services, Inc. Document Number: ME00213-08

TABLE 2-B: Reporting Limits (LOQ) – EPA 537-MOD Isotope Dilution (Solid)

Analyte Acronym	Analyte Name	CAS Number	Spiked Conc ¹ (µg/kg)	DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
EtFOSAA	N-ethylperfluoro-1-	2991-50-6	1	0.2	0.5	1
	octanesulfonamidoacetic acid					
8:2 FTS	Fluorotelomer sulfonate 8:2 [1H,1H,2H,2H-perfluorodecane sulfonate]	39108-34-4	0.96	0.3	0.6	2
4:2 FTS	Fluorotelomer sulfonate 4:2 [1H,1H,2H,2H-perfluorohexane sulfonate]	757124-72- 4 ²	0.93	0.3	0.6	2
6:2 FTS	Fluorotelomer sulfonate 6:2 [1H,1H,2H,2H-perfluorooctane sulfonate]	27619-97-2	0.95	0.3	0.6	2
MeFOSAA	N-methylperfluoro-1- octanesulfonamidoacetic acid	2355-31-9	1	0.2	0.5	1
PFBS	Perfluoro-1-butanesulfonate	375-73-5	0.88	0.1	0.5	1
PFBA	Perfluoro-n-butanoic acid	375-22-4	1	0.2	0.5	1
PFDS	Perfluoro-1-decanesulfonate	2806-15-7	0.96	0.2	0.5	1
PFDA	Perfluoro-n-decanoic acid	335-76-2	1	0.2	0.5	1
PFDoA	Perfluoro-n-dodecanoic acid	307-55-1	1	0.2	0.5	1
PFHpS	Perfluoro-1-heptanesulfonate	375-92-8	0.95	0.2	0.5	1
PFHpA	Perfluoro-n-heptanoic acid	375-85-9	1	0.2	0.5	1
PFHxS	Perfluoro-1-hexanesulfonate	355-46-4	0.91	0.2	0.5	1
PFHxA	Perfluoro-n-hexanoic acid	307-24-4	1	0.2	0.5	1
PFNS	Perfluoro-1-nonanesulfonate	98789-57-2	0.96	0.2	0.5	1
PFNA	Perfluoro-n-nonanoic acid	375-95-1	1	0.2	0.5	1
PFOS	Perfluorooctanesulfonate	1763-23-1	0.93	0.15	0.5	1
PFOSA	Perfluoro-1-octanesulfonamide	754-91-6	1	0.3	0.5	1
PFOA	Perfluoro-n-octanoic acid	335-67-1	1	0.15	0.5	1
PFPeA	Perfluoro-n-pentanoic acid	2706-90-3	1	0.2	0.5	1
PFPeS	Perfluoro-1-pentanesulfonate	2706-91-4	0.94	0.2	0.5	1
PFTeDA	Perfluoro-n-tetradecanoic acid	376-06-7	1	0.2	0.5	1
PFTrDA	Perfluoro-n-tridecanoic acid	72629-94-8	1	0.2	0.5	1
PFUdA	Perfluoro-n-undecanoic acid	2058-94-8	1	0.2	0.5	1
MeFOSA	N-methylperfluoro-1- octanesulfonamide	31506-32-8	1	0.3	0.6	2
EtFOSA	N-ethylperfluoro-1- octanesulfonamide	4151-50-2	1	0.3	0.6	2
10:2FTS	1H,1H,2H,2H-perfluorododecane sulfonate	120226-60- 0 ²	0.96	0.2	0.5	1
GenX	Tetrafluoro-2-(heptafluoropropoxy) propanoic acid	13252-13-6	2	0.5	1	4

¹Spiking concentration used to determine DL.

²CAS Numbers are for the acid and not the salt.

Shealy Environmental Services, Inc. Document Number: ME00213-08

TABLE 3: Labeled Standard Associations - Method 537-MOD Isotope Dilution (Aqueous and Solids)

Target Analyte	Associated Labeled Standard
4:2 FTS	13C2_4:2FTS_2
6:2 FTS	13C2_6:2FTS_2
8:2 FTS	13C2_8:2FTS_2
10:2FTS	13C2_8:2 FTS_2
EtFOSAA	d5-EtFOSAA
MeFOSAA	d3-MeFoSAA
PFBS	13C3_PFBS
PFBA	13C4_PFBA
PFDS	13C8_PFOS
PFDA	13C6_PFDA
PFDoA	13C2_PFDoA
PFHpS	13C3_PFOS
PFHpA	13C4_PFHpA
PFHxS	13C3_RFHxS
PFHxA	13C5_PFHxA
PFNS	13C8_PFOS
PFNA	13C9_PFNA
PFOS	13C8_PFOS
PFOSA	13C8_PFOSA
PFOA	13C8_PFOA
PFPeA	13C5_PFPeA
PFPeS	13C3_PFBS
PFTeDA	13C2_PFTeDA
PFTrDA	13C2_PFDoA
PFUdA	13C7_PFUdA
MeFOSA	d3-MeFOSA
EtFOSA	d5-EtFOSA
GenX	13C3-GenX

NOTE: For method 537 MOD-ID, the labeled quantitation standards are contained in the SUR solution.

TABLE 4: Method 537-MOD ID Instrument Conditions (Aqueous and Solids)

LC Program

Step	Total Time (min)	Flow Rate (uL/min)	A: 20mM Ammonium Acetate (%)	B: Methanol (%)
0	0.00	600	95.0	5.0
1	0.10	600	45.0	55.0
2	4.50	600	1.0	99.0
3	8.00	600	1.0	99.0
4	8.50	600	95.0	5.0
5	11.00	600	95.0	5.0

Built-in Diverter Valve Program

Step	Total Time (min)	Position
1	0.5	Waste
2	2.0	MS
3	7.5	Waste

Instrument Parameters

Parameter	Setting or Value					
Syringe Size	100 μL					
Injection Volume	10 μL					
Draw Speed	50.0 μL/min					
Eject Speed	50.0 μL/min					
Needle Level	3.0 mm					
Column Oven	40°C					
Temperature	40 C					
MRM Scan Window	30 sec					
Curtain Gas (CUR)	30.0					
Collision Gas (CAD)	9					
Ion Spray Voltage (IS)	-4500.0 V					
Temperature (TEM)	450.0°C					
Ion Source Gas 1 (GS1)	40.0					
Ion Source Gas 2 (GS2)	60.0					

MS/MS Conditions

ID	Q1 Mass	Q3 Mass	Time	DP (volts)	EP	CE	CXP
	(Da)	(Da)	(min)	` ′	(volts)	(volts)	(volts)
4:2 FTS	327	307	3.46	-20	-4	-28	-8
4:2 FTS_2	327	81	3.46	-20	-4	-50	-8
6:2 FTS	427	407	4.23	-20	-4	-32	-8
6:2 FTS_2	427	81	4.23	-20	-4	-72	-8
8:2 FTS	527	507	4.91	-20	-4	-40	-8
8:2 FTS_2	527	81	4.91	-20	-4	-82	-8
10:2 FTS	627	607	5.49	-20	-8	-45	-8
10:2 FTS_2	627	80	5.49	-20	-8	-92	-8
EtFOSA	526	169	5.49	-50	-10	-37	-8
EtFOSA_2	526	219	5.49	-50	-10	-37	-8
GenX	329	169	3.80	-30	-10	-18	-7
GenX_2	329	185	3.80	-30	-10	-32	-12
MeFOSA	512	169	5.33	-50	-10	-37	-8
MeFOSA_2	512	219	5.33	-50	-10	-37	-8
N-EtFOSAA	584	419	5.22	-50	-10	-28	-8
N-EtFOSAA_2	584	526	5.22	-50	-10	-28	-8
N-MeFOSAA	570	419	5.07	-50	-10	-28	-8
N-MeFOSAA_2	570	483	5.07	-50	-10	-22	-8
PFBA	212.9	168.9	2.63	-10	-8	-12	-8
PFBS	298.9	80	3.19	-20	-4	-56	-5.5
PFBS 2	298.9	99	3.19	-20	-4	-46	-9
PFDA	513	469	4.92	-10	-8	-17	-8
PFDA_2	513	169	4.92	-10	-8	-27	-8
PFDoA	613	569	5.48	-10	-8	-18	-8
PFDoA_2	613	169	5.48	-10	-8	-30	-8
PFDS	599	80	5.2	-20	<u>-7</u>	-118	-5.5
PFDS_2	599	99	5.2	-20	-7	-95	-9
PFHpA	363	319	3.88	-10	-8	-14	-8
PFHpA_2	363	169	3.88	-10	-8	-25	-8
PFHpS	449	80	4.26	-20	- - -4	-80	-5.5
PFHpS_2	449	99	4.26	-20	- 4 -4	-70	-9 -9
PFHxA	313	269	3.5	-10	-8	-14	-8
PFHxA_2	313	119	3.5	-10	-8	-25	-8
PFHxS	313	80	3.9	-20	- - -4	-23 -74	-5.5
PFHxS 2	399	99	3.9	-20	- 4 -4	-60	-5.5 -9
PFNA	463	419	4.6	-10	-8	-16	-8
PFNA 2	463	169	4.6	-10	- 8	-26	-8
PFNS	549	80	4.0	-20		-115	-6 -5.5
PFNS_2	549	99	4.91	-20	-5.5 -5.5	-115 -92	-5.5 -5.5
	413	369	4.91	-20	-5.5 -8	-92 -14	-5.5 -8
PFOA 2	413	169	4.25	-10	-8 -8		-8 -8
PFOA_2	413				-8 -4	-26	
PFOS 2		80	4.59	-20	•	-95	-5.5
PFOS_2	499	99	4.59	-20	-4	-87	-9
PFOSA	498	78	4.89	-20	-4	-85	-8

MS/MS Conditions Continued								
ID	Q1 Mass (Da)	Q3 Mass (Da)	Time (min)	DP (volts)	EP (volts)	CE (volts)	CXP (volts)	
PFPeA	262.9	218.9	3.12	-10	-8	-13	-8	
PFPeS	349	80	3.54	-20	-4	-70	-5.5	
PFPeS_2	349	99	3.54	-20	-4	-60	-9	
PFTeDA	713	669	5.92	-10	-4	-22	-8	
PFTeDA_2	713	169	5.92	-10	-4	-38	-8	
PFTrDA	663	619	5.72	-10	-4	-20	-8	
PFTrDA_2	663	169	5.72	-10	-4	-36	-8	
PFUdA	563	519	5.22	-10	-8	-18	-8	
PFUdA_2	563	169	5.22	-10	-8	-28	-8	
13C2_PFDA	515	470	4.92	-10	-8	-17	-8	
13C2 PFDoA	615	570	5.48	-10	-4	-18	-8	
13C2_PFHxA	315	270	3.5	-10	-8	-14	-8	
13C2_PFOA	415	370	4.25	-10	-8	-14	-8	
13C2_PFTeDA	715	670	5.92	-10	-4	-22	-8	
13C3_GenX	332	169	3.80	-30	-10	-19	-10	
13C3_PFBA	216	172	2.63	-10	-8	-12	-8	
13C3_PFBS	302	80	3.19	-20	-4	-56	-5.5	
13C3_PFHxS	402	80	3.9	-20	-4	-74	-5.5	
13C4_PFBA	217	172	2.63	-10	-8	-12	-8	
13C4_PFHpA	367	322	3.88	-10	-8	-14	-8	
13C4_PFOS	503	80	4.59	-20	-4	-95	-5.5	
13C5_PFHxA	318	273	3.5	-10	-8	-14	-8	
13C5_PFPeA	267.9	223	3.12	-10	-8	-13	-8	
13C6_PFDA	519	474	4.92	-10	-8	-16	-8	
13C7_PFUdA	570	525	5.22	-10	-8	-18	-8	
13C8_PFOA	421	376	4.25	-10	-8	-14	-8	
13C8_PFOS	507	80	4.59	-20	-4	-95	-5.5	
13C8_PFOSA	506	78	4.89	-20	-4	-85	-8	
13C9_PFNA	472	427	4.6	-10	-8	-16	-8	
d3MeFOSA	515	169	5.33	-50	-10	-37	-8	
d3-MeFOSAA	573	419	5.07	-50	-10	-28	-8	
d5EtFOSA	531	169	5.49	-50	-10	-37	-8	
d5-EtFOSAA	589	419	5.22	-50	-10	-28	-8	
M2-4:2 FTS	329	309	3.46	-20	-4	-28	-8	
13C2-4:2 FTS 2	329	81	3.46	-20	-4	-28	-8	
M2-6:2FTS	429	409	4.23	-20	-4	-32	-8	
13C2-6:2FTS_2	429	81	4.23	-20	-4	-32	-8	
M2-8:2FTS	529	509	4.91	-20	-4	-40	-8	
13C2-8:2FTS 2	529	81	4.91	-20	-4	-82	-8	
	Sec Append						U	

NOTE: See Appendix E for the chemical derivation of the ion transitions.

Shealy Environmental Services, Inc.

Page 35 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

TABLE 5: Calibration Levels (ng/L) –EPA 537 MOD ID ICAL (Aqueous and Solids)

Analyte	Level	Level	Level	Level	Level	Level	Level	Level	
	1	2	3	4	5	6	7	8	
	PFAS	S Full	PFAS	Full Li	st Native	e PDS	PFAS Full		
	List N	Native		Mix,	100X		List Native		
	PDS	Mix,					PDS	Mix,	
	100	00X					10	X	
PFBA	50	100	200	500	1000	2000	5000	10000	
PFPeA	50	100	200	500	1000	2000	5000	10000	
PFBS	44	88	177	442	884	1768	4420	8840	
PFHxA	50	100	200	500	1000	2000	5000	10000	
PFPeS	50	100	200	500	1000	2000	5000	10000	
PFHpA	50	100	200	500	1000	2000	5000	10000	
PFHxS	46	91	182	455	910	1820	4550	9100	
PFOA	50	100	200	500	1000	2000	5000	10000	
PFHpS	48	95	190	476	952	1904	4760	9520	
PFNA	50	100	200	500	1000	2000	5000	10000	
PFOS	46	93	186	464	928	1856	4640	9280	
PFDA	50	100	200	500	1000	2000	5000	10000	
PFNS	48	96	192	480	960	1920	4800	9600	
4:2FTS	47	93	187	467	934	1868	4670	9340	
6:2FTS	47	95	190	474	948	1896	4740	9480	
8:2 FTS	48	96	192	479	958	1916	4790	9580	
FOSA	50	100	200	500	1000	2000	5000	10000	
MeFOSA	50	100	200	500	1000	2000	5000	10000	
EtFOSA	50	100	200	500	1000	2000	5000	10000	
PFUDA	50	100	200	500	1000	2000	5000	10000	
MeFOSAA	50	100	200	500	1000	2000	5000	10000	
EtFOSAA	50	100	200	500	1000	2000	5000	10000	
PFDS	48	96	193	482	964	1928	4820	9640	
PFDoA	50	100	200	500	1000	2000	5000	10000	
10:2FTS	48	96	193	482	964	1928	4820	9640	
PFTrDA	50	100	200	500	1000	2000	5000	10000	
PFTeDA	50	100	200	500	1000	2000	5000	10000	
GenX	100	200	400	1000	2000	4000	10000	20000	
Surrogates (SUR)	1000	1000	1000	1000	1000	1000	1000	1000	
Internal Standards (IS)	1000	1000	1000	1000	1000	1000	1000	1000	

NOTE: See Table 1 for method specific target analytes.

NOTE: The 537 MOD ID (Aqueous and Solid) SUR includes the following compounds:

- Perfluoro-n-[1,2-13C2] hexadecanoic acid (M2PFHxDA or 13C2PFHxDA)
- Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] hexane sulfonate (M2-4:2FTS or 13C2-4:2FTS)
- Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] octane sulfonate (M2-6:2FTS or 13C2-6:2FTS)
- Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] decane sulfonate (M2-8:2FTS or 13C2-8:2FTS)
- Perfluoro-1-[13C8] octanesulfonamide (M8FOSA-I or 13C8FOSA)

Shealy Environmental Services, Inc.

Page 36 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

- N-ethyl-d5-perfluoro-1-octanesulfonamide (d-N-EtFOSA-M)
- N-methyl-d3-perfluoro-1-octanesulfonamide (d-N-MeFOSA-M)
- N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid (d5-N-EtFOSAA)
- N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid (d3-N-MeFOSAA)
- Perfluoro-n-[13C4]butanoic acid (MPFBA or 13C4PFBA)
- Perfluoro-n-[13C5]pentanoic acid (M5PFPeA or 13C5PFPeA)
- Perfluoro-n-[1,2,3,4,6-13C5]hexanoic acid (M5PFHxA or 13C5PFHxA)
- Perfluoro-n-[1,2,3,4-13C4]heptanoic acid (M4PFHpA or 13C4PFHpA)
- Perfluoro-n-[13C8]octanoic acid (M8PFOA or 13C8PFOA)
- Perfluoro-n-[13C9]nonanoic acid (M9PFNA or 13C9PFNA)
- Perfluoro-n-[1,2,3,4,5,6-13C5]decanoicanoic acid (M6PFDA or 13C6PFDA)
- Sodium perfluoro-1-[2,3,4-13C3]butanesulfonate (M3PFBS or 13C3PFBS)
- Sodium perfluoro-1-[1,2,3-13C3]hexanesulfonate (M3PFHxS or 13C3PFHxS)
- Sodium perfluoro-1-[13C8]octanesulfonate (M8PFOS or 13C8PFOS)
- Perfluoro-n-[1,2,3,4,5,6,7-13C7]undecanoic acid (M7PFUdA or 13C7PFUdA)
- Perfluoro-n-[1,2-13C2]dodecanoic acid (MPFDoA or 13C2PFDoA)
- Perfluoro-n-[1,2-13C2]tetradecanoic acid (M2PFTeDA or 13C2PFTeDA).
- Tetrafluoro-2-(heptafluoropropoxy)-13C3 propanoic acid (13C3-GenX)

NOTE: The 537 MOD ID (Aqueous and Solid) IS includes the following compounds:

- Perfluoro-n-[1,2-13C2]hexanoic acid (M2PFHxA or 13C2PFHxA)
- Perfluoro-n-[2,3,4-13C3]butanoic acid (M3PFBA or 13C3PFBA)
- Perfluoro-n-[1,2-13C2]octanoic acid (M2PFOA or 13C2PFOA)
- Perfluoro-n-[1,2-13C2]decanoic acid (MPFDA or 13C2PFDA)
- Sodium perfluoro-1-[1,2,3,4-13C4]octanesulfonate (MPFOS or 13C4PFOS)

Shealy Environmental Services, Inc. Document Number: ME00213-08

Page 37 of 69 Effective Date: 6/20/2018

Appendix B. Method 537 MOD ID (Solids)

1. Standard Preparation

- 1.1 Internal standards for Method 537-MOD ID (solids) are the following five compounds: Perfluoro-n-[1,2-13C2]hexanoic acid (13C2-PFHxA), Perfluoro-n-[1,2-13C2] octanoic acid (13C2-PFOA) and Sodium perfluoro-1-[1,2,3,4-13C4]octanesulfonate (13C4-PFOS), Perfluoro-n-[2,3,4-13C3] butanoic acid (13C3-PFBA) and Perfluoro-n-[1,2-13C2] decanoic acid (13C2-PFDA).
- 1.2 Internal Standard (IS) 50X Mix: dilute the stock standard with methanol/water in accordance to section 1.9 and the table below:

537 MOD ID (Solids) IS 50X Mix

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.
	μg/mL	μL	mL	μg/mL
Perfluoro-n-[1,2-13C2]hexanoic acid (13C2-PFHxA)	50	200.0	10.0	1.0

1.3 20 ppb IS Mix: combine the IS 50X mix in section 1.2 and Wellington Labs standard part# MPFAC-C-IS and dilute with methanol/water in accordance to section 1.9 and the table below:

537 MOD ID (Solids) 20 ppb IS Mix

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.	
	μg/mL	μL	mL	μg/mL	
MOD-ID IS 50X Mix	1	200.0	10.0	0.020	
MPFAC-C-IS stock	2	100.0	10.0	0.020	

1.4 SUR 50X Mix: Dilute the stock standards with methanol/water in accordance to section 1.9 and the table below:

537 MOD ID (Solids) SUR 50X Mix

Standard Name	Conc. of	Aliquoted	Dilution	Final
Standard Ivanie		ı - 1		
	Stock Std.	Volume	Volume	Conc.
	μg/mL	μL	mL	μg/mL
Perfluoro-n-[1,2-13C2] hexadecanoic acid (13C2-PFHxDA)	50	200.0	10.0	1.0
Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] hexane sulfonate (M2-4:2FTS)	50	200.0	10.0	1.0
Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] octane sulfonate (M2-6:2FTS)	50	200.0	10.0	1.0
Sodium 1H, 1H, 2H, 2H-perfluoro-[1,2-13C2] decane sulfonate (M2-8:2FTS)	50	200.0	10.0	1.0
Perfluoro-1-[13C8] octanesulfonamide (13C8-PFOSA)	50	200.0	10.0	1.0
N-ethyl-d5-perfluoro-1-octanesulfonamide (d5-EtFOSA)	50	200.0	10.0	1.0
N-methyl-d3-perfluoro-1-octanesulfonamide (d3-MeFOSA)	50	200.0	10.0	1.0
N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid (d5-EtFOSAA)	50	200.0	10.0	1.0
N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid (d3-MeFOSAA)	50	200.0	10.0	1.0

Shealy Environmental Services, Inc.
Document Number: ME00213-08

1.5 20 ppb SUR mix: combine the SUR 50X mix in section 1.4 and Wellington Labs standard part# MPFAC-C-ES and dilute with methanol/water in accordance to section 1.9 and the table below:

Page 38 of 69

Effective Date: 6/20/2018

537 MOD ID (Solids) 20 ppb SUR Mix

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.
	μg/mL	μL	mL	μg/mL
MOD ID SUR 50X mix	1	200.0	10.0	0.020
MPFAC-C-ES stock	2	100.0	10.0	0.020

1.6 100 ppb SUR mix: combine the SUR 50X mix in section 1.4 and Wellington Labs standard part# MPFAC-C-ES and dilute with methanol/water in accordance with section 1.9 and the table below:

537 MOD ID (Solids) 100 ppb SUR Mix

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.
	μg/mL	μL	mL	μg/mL
MOD ID SUR 50X mix	1	1000	10.0	0.10
MPFAC-C-ES stock	2	500	10.0	0.10

NOTE: The compounds included in the 537 MOD ID (Aqueous and Solid) SUR Mix are listed under Table 5.

1.7 Solid Spiking Standard (SSS) – For Method 537-MOD ID (solids), a separate solution of target analytes will be prepared and used to spike all QC samples (LCS, MS/MSD) prior to extraction. The concentration of all target analytes will be 1000 ng/mL, except GenX which will be 2000 ng/mL. The SSS is stable for 6 months when stored at 2-6°C. Prepare according to section 1.9 and the table below:

537 MOD ID Solid Spiking Standard (SSS)

Standard Name	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.
	ng/mL	μL	mL	ng/mL
PFAC-24PAR	2000	1100	2.2	1000
MeFOSA	50000	44	2.2	1000
EtFOSA	50000	44	2.2	1000
10:2 FTS	50000	44	2.2	1000
GenX	50000	88	2.2	2000

- 1.8 Analyte Primary Dilution Standard (PDS) Solutions For method 537-MOD ID (solids), a list of these solutions is provided below. The PDS standards are stable for two weeks when stored at room temperature, or 6 months when stored at 2-6°C. This expiry can be extended up to a total of 12 months if a verification of ICAL standards (made with these PDS solutions) versus the ICV gives 85 115% recovery for all analytes. Wellington Laboratories item #s for the standards used to prepare the PDS solutions are as follows: PFAC-24PAR (24 compound mix of native PFAS); N-MeFOSA-M; N-EtFOSA-M; 10:2FTS; HFPO-DA (GenX)
 - 1.8.1 Stock (10X) Analyte PDS (containing all target analytes at 0.2 ug/mL, GenX at 0.4 μg/mL) 1 mL of the primary lot of PFAC-24PAR standard mix, 40 uL of MeFOSA, EtFOSA, and 10:2

Shealy Environmental Services, Inc.

Page 39 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

FTS primary standards, and 80 uL of GenX primary standard are diluted to 10 mL with 8.4 mL of methanol and 400 uL reagent water.

- 1.8.2 100X Analyte PDS (containing all target analytes at 20 ng/mL; GenX at 40 ng/mL) 1 mL of Stock (10X) Analyte PDS is diluted to 10 mL with 9 mL of 96% MeOH
- 1.8.3 1000X Analyte PDS (containing all target analytes at 2.0 ng/mL; GenX at 4.0 ng/mL) 1 mL of 100X Analyte PDS is diluted to 10 mL with 9 mL of 96% MeOH
- 1.9 Initial Calibration Standards (ICAL) Using the standards in sections 1.3, 1.5, and 1.7 and according to the table below prepare calibration standards at the following concentrations in pg/mL (ng/L): 50, 100, 200, 500, 1000, 2000, 5000, and 10000, except GenX which will be at double these concentrations. The ICAL standards are stable for two weeks when stored at room temperature, or 6 months when stored at 2-6°C. This expiry can be extended up to a total of 12 months if a verification versus the ICV gives 85 115% recovery for all analytes. The final compositions of the above solutions contain 96:4% (vol/vol) methanol: water. See Table 5 for a list of analytes and exact concentrations.

537 MOD ID (Solids) ICAL Preparation

PFAS Conc. (pg/mL)	SUR Conc. (pg/mL)	IS Conc. (pg/mL)	PFAS FL PDS 10X	PFAS FL PDS 100X	PFAS FL PDS 1000X	20 ppb SUR	20 ppb IS	Final Volume
	(Pg/IIII)	(Pg/III2)	mL	mL	mL	mL	mL	mL
50	1000	1000	- /		0.125	0.25	0.25	5.00
100	1000	1000	-		0.250	0.25	0.25	5.00
200	1000	1000	/-	-	0.500	0.25	0.25	5.00
500	1000	1000		0.125	-	0.25	0.25	5.00
1000	1000	1000	-	0.250	-	0.25	0.25	5.00
2000	1000	1000	-	0.500	-	0.25	0.25	5.00
5000	1000	1000	0.125	-	-	0.25	0.25	5.00
10000	1000	1000	0.25	-	-	0.25	0.25	5.00

- 1.10 The final composition for all the standards in sections 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8 and 1.9 contains 96:4% (v/v) methanol/water.
- 1.11 Initial Calibration Verification (ICV) –Prepare the ICV according to the sections and the table below. The final composition of the solutions below contains 96:4% (vol/vol) methanol:water.
 - 1.11.1 100X ICV Mix (second source standard containing required target analytes at 0.02 ug/mL or 20ppb; GenX at 0.1 ug/mL or 100ppb) 100 uL of the secondary lot (different than the lot used to prepare the PDS solutions) of PFAC-24PAR standard mix and 20 uL of GenX secondary standard is diluted to 10 mL with 9.88 mL of methanol. The PFAC-24PAR standard includes all analytes listed in Table 5 except the following: MeFOSA, EtFOSA, 10:2FTS.

Shealy Environmental Services, Inc.

Page 40 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

1.11.2 ICV Sample Solution (500ppt; GenX at 2500ppt) – combine the solutions in sections 7.2.1.2, 7.2.2.2 and 7.4.1 according to the table below. The final solvent composition of this solution should be 96:4% MeOH: water.

	PFAS 537- MOD (Solids) ICV Preparation									
Compound	Conc. of Stock Std.	Aliquoted Volume	Dilution Volume	Final Conc.						
	pg/mL	μL	mL	pg/mL						
PFAS ICV 100X Mix	20000	25	1.0	500						
Full List SUR mix, 20ppb	20000	50	1.0	1000						
Full List IS mix, 20ppb	20000	50	1.0	1000						

- 1.12 Instrument Blank Instrument Blank (IBLK) The instrument blank is prepared by spiking 180 μ L 96% MeOH with 10 μ L of 20ppb IS Mix and 10 μ L of 20 ppb SUR Mix. Cap and vortex to mix.
- 1.13 Method Blank (MB) Weigh 1.0g of Ottawa sand into a pre-tared 15mL Falcon tube and spike with 110µL of 100ppb SUR mix. Mix well. Extract as normal alongside client samples.
- 1.14 Continuing Calibration Verification/Instrument Sensitivity Check (CCV/ISC) The CCV and the ISC are prepared in the same manner. The daily Instrument Sensitivity Check (ISC; DOD required) will be used as the daily opening CCV, and will be analyzed at both the 100ppt and 200ppt levels using prepared ICAL standards. The prepared ICAL standard at the 1000ppt level will be used as the CCV to be analyzed every ten samples and at the conclusion of the analytical run, as closing CCV. Analyte concentrations must be within +/-30% of their true values.
- 1.15 Laboratory Control Sample (LCS) The LCS is prepared by spiking approximately 1g of Ottawa sand with 55 μ L of Solid Spiking Standard (1000 ng/mL), for a concentration of 55 μ g/kg (55000 pg/g; 55000 ng/kg; 55 ng/g). The LCS is also spiked with 110 μ L of Full List SUR mix (100 ppb) and extracted as normal alongside client samples.
- 1.16 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Client samples are spiked in the same manner as an LCS. 1g of sample is spiked with 55 μ L of Solid Spiking Standard (1000 ng/mL) for a concentration of 55 μ g/kg plus 110 μ L of Full List SUR mix (100ppb) and extracted as normal alongside other client samples.
- 1.17 Method Detection Limit (MDL) MDL sample preparation and analysis will be performed over three separate days. Each MDL sample will be extracted with an equal number of MB samples. The MDL is prepared by spiking approximately 1g of Ottawa sand with 50 μ L of 100X PDS mix for a concentration of 1000 pg/g (1000 ng/kg; 1 μ g/kg), plus 110 μ L of Full List SUR mix (100ppb) and extracted as normal. An equal number of MB (see section 1.12 above) will be extracted and analyzed with MDL samples.
- 1.18 Initial (and Continuing) Demonstration of Capability (IDOC/CDOC) The IDOC/CDOC is prepared by spiking approximately 1g of Ottawa sand with 55 μL of Solid Spiking Standard (SSS) plus 110μL of Full List SUR mix (100ppb) and extracted as normal. IDOC/CDOC sample final concentration equals 55μg/kg.

Shealy Environmental Services, Inc.

Page 41 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

1.19 Ammonia-Methanol (Amm-MeOH, 0.3%) – In a 500 mL class A volumetric flask add 6.76 mL NH₄OH (Ammonium Hydroxide) and fill to volume with reagent water (493.24 mL reagent MeOH). Invert to mix.

2. Sample Preparation

- 2.1 Allow samples time to come to room temperature.
- 2.2 Mix sample with a tongue depressor and/or vigorously shake sample container to ensure sample homogeneity.
- 2.3 Weigh approximately 1.0 g of sample into a pre-tared 15 mL Falcon tube, record sample weight.
- 2.4 Spike sample aliquot with 110 μ L 100ppb SUR mix; spike QC samples appropriately (LCS, MS/MSD spiked with 55 μ L of SSS)
- 2.5 Add 4 mL MeOH and 4 mL 0.3% Amm-MeOH to sample tube and cap tightly.
- 2.6 Place sample tubes on orbital shaker table for 30-35mins, on level 9.
- 2.7 Place samples in a tray and place the tray in a sonic bath at room temperature, sonicate for 30-35mins.
- 2.8 Place samples in a centrifuge and centrifuge at 3000RPM for 5 mins.
- 2.9 Decant the resultant supernatant from original sample tube into a clean centrifuge tube, either by pouring or using a plastic pipette.
- 2.10 Place Envi-Carb SPE tubes, labelled for each sample, into individual active luer ports in the vacuum manifold top.
- 2.11 Wet rim of manifold body and place manifold top on manifold body. Start the vacuum pump and ensure that a proper seal is formed between the manifold top and body, and vacuum is at a proper level (approximately 5in. Hg).
- 2.12 Condition the Envi-Carb tubes by passing 3mL MeOH in a drop-wise fashion through the tube, discard eluent. Do not dry tubes.
- 2.13 Release vacuum and remove manifold top. Place a rack containing clean, labelled 15mL Falcon tubes in the manifold body and replace the top. Ensure that the correct luer is inserted into the corresponding falcon tube in the manifold body.
- 2.14 Start vacuum and ensure proper seal and vacuum are achieved.

Shealy Environmental Services, Inc.

Page 42 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

2.15 Load decanted extracts into corresponding labelled Envi-Carb tubes and begin passing the extracts through the tube in a drop-wise fashion; collect in the previously positioned clean, labelled 15mL Falcon tubes. Not all of the extract will fit at once in the tube, so be ready to load the remainder.

- 2.16 When the entire extract has eluted through the tube, close the stopcock to keep the tube from drying during the following steps.
- 2.17 Rinse each tube with 1mL of MeOH and collect.
- 2.18 Repeat the tube rinse with a second 1mL aliquot of MeOH and collect.
- 2.19 Release vacuum, remove manifold top from body, and remove collection tubes. Cap tubes until ready to prepare autosampler vials for injection.
- 2.20 Add 8μL of reagent water, 10μL of IS mix, and 182μL of extract to a clean, labelled polypropylene autosampler vial. Cap and vortex to mix. Ensure there is not an air bubble trapped at the bottom of the insert. This vial is ready for analysis.
- 2.21 Correction Factors Correction Factors (CF) will be multiplied by the calculated concentration (Sec. 12.2 of main SOP body) measured by the instrument in order to calculate the actual concentration in the original sample. CF is based on total sample weight extracted, fraction of dry solids in sample, and final extract volume. Multiplying by 1000 adjusts the CF so that the actual concentration calculated in the original sample has the unit μg/kg instead of pg/g. The percent solids will be determined as described in SOP ME0013F-03. The CF for solid samples will be calculated as follows:

$$CF = ((V_E/(M \times S)) \times DF) \times 1000$$

Where:

V_E is the final extract volume (mL)
M is the mass of sample extracted (g)
S is the percent solids of the sample (as a decimal)
DF is the dilution factor. For undiluted analysis, DF = 1/0.91

Shealy Environmental Services, Inc.

Page 43 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

Appendix C. Aqueous Serial Dilution

1 Standard Preparation

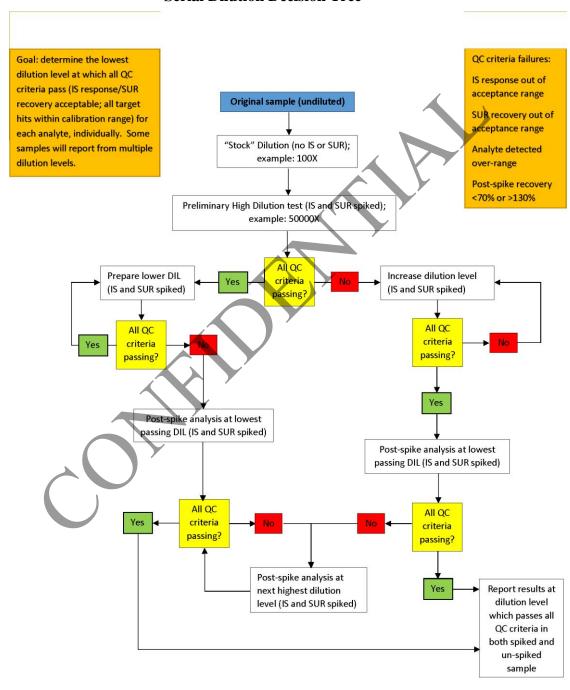
- 1.1 IS, SUR, and ICV standard solutions prepared for 537 MOD-ID (aqueous) are used for samples analyzed by serial dilution instead of SPE. See Section 7 in the main body of the SOP for more information on preparation and contents of these solutions.
- 1.2 Dilutions of individual analyte stock standards are used for fortifying post-spike samples. Typically, these diluted stocks are prepared by a two-step serial dilution for a nominal concentration of 5ppb (some analytes have different concentrations due to differing stock concentrations). These diluted stocks are prepared by diluting 10uL of stock solution with 950uL of MeOH and 40uL of reagent water (FV=1mL), then further diluting 10uL of this initial 100X solution with 990uL of 96% MeOH, for a final dilution of 10,000X. The 10,000X DIL stock solution will typically be used for fortifying post-spike samples.
- 1.3 ICALs, ICAL standards, and instrument QC (CCVs, IBLKs) are the same as for 537 MOD-ID (aqueous) and all acceptance criteria used for 537 MOD-ID applies.
- 1.4 Samples analyzed by serial dilution do not require an LCS or MB to be prepared alongside the samples, as no extraction is performed. Daily IBLKs take the place of MBs.
- 2 Sample Preparation Samples of known high PFAS concentrations can be prepared by serial dilution instead of SPE, with documented project approval.
 - 2.1 All solutions prepared for instrumental analysis in this section and Section 3 shall have a solvent composition of 96:4% MeOH:water.
 - 2.2 An initial dilution of the sample is made up with no IS or SUR added, to be used as the base dilution for successive serial dilutions. This initial dilution is typically prepared at 100X.
 - 2.3 Using the initial sample dilution, prepare a high dilution (e.g. 50,000X) and analyze it to determine the approximate concentration of target analytes in the samples. Use the information obtained from this analysis to determine the next serial dilution to be prepared. Be sure to include IS and SUR standards at the appropriate concentration in each analyzed serial dilution. IS/SUR compounds should typically be present at a concentration of 1000pg/mL (1ppb).
 - 2.4 Prepare successively lower dilutions of each serial dilution sample until all target analytes fail for over-range detection, IS response being out of acceptance, and/or SUR recovery being out of acceptance. Use the Non-Extracted Method PFAS Serial Dilution Prep Log and Post-spike Log (ME002DR) to record dilution and post-spike preparations. Be sure to include IS and SUR standards at the appropriate concentration in each analyzed serial dilution. No serial dilution samples will be analyzed at a dilution below 25X, in order to maintain proper solvent composition in the analyzed sample.

NOTE: Each target analyte should be evaluated individually in each serial dilution preparation. Associated IS/SUR compounds must pass acceptance criteria for an individual analyte to be reported. If the associated SUR and/or IS for one compound fails in a dilution sample, but *any* others pass, further dilution analysis will be necessary. Once a dilution level is reached in which all targets fail for one of the above-stated reasons, analysis will begin on the post-spiked samples.

Shealy Environmental Services, Inc. Document Number: ME00213-08

2.5 For each target analyte, determine the dilution level at which the sample fails for one of the reasons stated in Section 2.4. The corresponding post-spike sample should be prepared at the next highest dilution level; in other words, determine the lowest dilution level at which a target analyte and its corresponding IS/SUR pass and prepare post-spike samples beginning at that dilution level.

Serial Dilution Decision Tree



Post-spike sample preparation – Post-spike samples must be prepared for all serial dilution samples which are ND for any target analyte at the reported dilution level. Non-detected target analytes will be

Shealy Environmental Services, Inc.

Page 45 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

individually spiked into post-spike dilution preparations at an expected on-column concentration equal to the stated LOQ in order to validate the stated LOQ in the sample matrix. If an analyte is detected in a reportable dilution, no post-spiking of that analyte is required; the LOQ will equal the stated LOQ times the dilution factor of the reported analysis.

- 3.1 Post-spike samples must be prepared at the same dilution level as the reported sample results, and spiked at a concentration equivalent to the LOQ in the diluted sample. Post-spike analysis shall be prepared and evaluated for EACH non-detected analyte in EACH sample.
- 3.2 Calculate the appropriate amount of 10000X DIL stock solution necessary for the post-spike preparation by using the following equation:

Spike Volume (mL) =
$$\underline{LOQ(pg/mL) * final volume(mL)}$$

DIL stock(pg/mL)

3.3 Calculate the appropriate amount of 20ppb SUR and 20ppb IS necessary for the post-spike preparation by using the following equation:

Spike Volume(mL) =
$$\frac{1000(pg/mL) * final volume(mL)}{20000(pg/mL)}$$

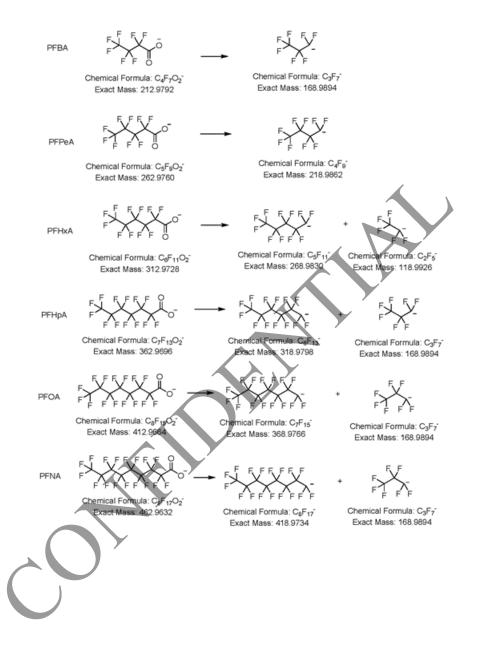
- 3.4 Prepare post-spikes at the reported dilution level for all ND analytes and record all post-spike preparation information using ME002DR. Use this logbook to ensure final volumes are correct and that all post-spike samples have solvent concentrations of 96% MeOH.
 - 3.4.1 The analyte post-spiked into the dilution preparation must recover within 70-130% in order to be acceptable/reportable. All other QC criteria must be met as well (IS, SUR passing; opening/closing CCVs passing; acceptable IBLK).
 - 3.4.2 Only the sample being spiked and its corresponding IS/SUR must pass for each individual post-spike sample to be acceptable.
 - 3.4.3 If a spiked analyte does not meet the 70-130% recovery limit, re-prepare the post-spike sample at successively higher dilutions using the steps above until recovery is within acceptance limits and corresponding IS/SUR compounds pass.
- 3.5 When a post-spike sample passes recovery and other QC criteria for the specific analyte(s) spiked, post-spiking analysis is complete for that sample/analyte combination.
- 3.6 The dilution reported for any individual analyte shall be the same dilution at which the post-spike sample passes for that analyte. If the initial post-spike sample fails when prepared at the expected reportable sample dilution, the LOQ has not been validated for this dilution level. Therefore, the reported dilution for that analyte/sample will be elevated to match the lowest passing dilution level of the post-spike analysis.
- 3.7 Report analyte results from the lowest dilution level which passes for all sample and post-spike QC criteria. The LOQ for ND analytes will equal the stated LOQ times the reported dilution factor.

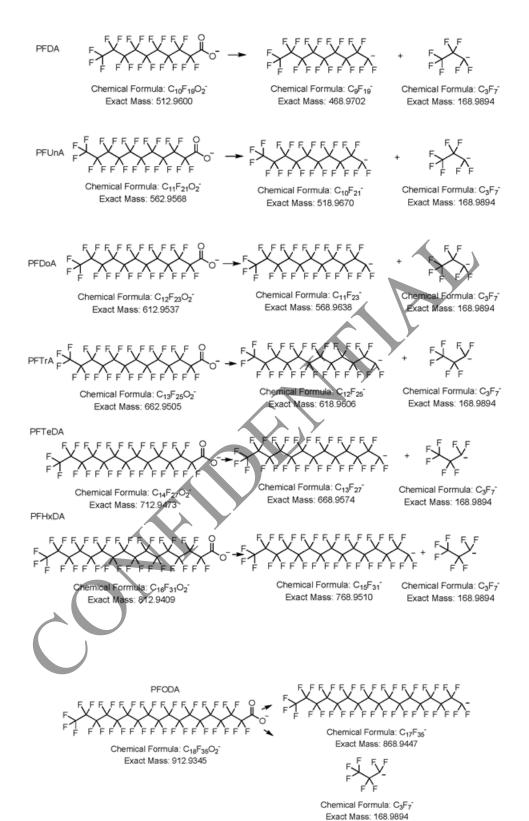
Appendix D. Extract Dilution Preparations

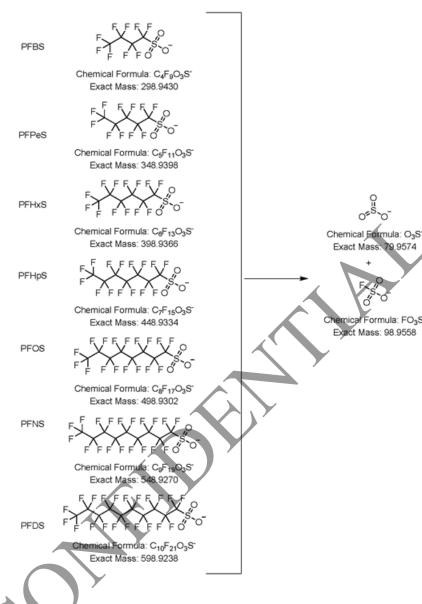
537	<u>1X</u>	<u>5X</u>	10X	20X	50X	100X	200X	500X	1000X	2000X
EXTRACT										
(uL)	950	200	100	50	20	10	20	8	4	2
IS (uL)	50	40	45	47.5	49	49.5	199	199.6	199.8	199.9
96% MeOH (uL)		760	855	902.5	931	940.5	3781	3792.4	3796.2	3798.1
TOTAL (uL)	1000	1000	1000	1000	1000	1000	4000	4000	4000	4000
CF calc	1/Vol	1/(Vol*0.2)	1/(Vol*0.1)	1/(Vol*0.05)	1/(Vol*0.02)	1/(Vol*0.01)	1/(Vol*0.005)	1/(Vol*0.002)	1/(Vol*0.001)	1/(Vol*0.0005)
ID Aq	<u>1X</u>	<u>5X</u>	<u>10X</u>	<u>20X</u>	<u>50X</u>	<u>100X</u>	<u>200X</u>	<u>500X</u>	1000X	<u>2000X</u>
EXTRACT (uL)	182	200	100	50	20	10	20	8	4	2
IS (uL)	10	50	50	50	50	50	200	200	200	200
SUR (uL)	0	40	45	47.5	49	49.5	199	199.6	199.8	199.9
MeOH (uL)	8	674	769	816.5	845	854.5	3437	3448	3452	3454
WATER (uL)	0	36	36	36	36	36	144	144	144	144
TOTAL (uL)	200	1000	1000	1000	1000	1000	4000	3999.6	3999.8	3999.9
	(1/0.91)* (FV/V _o)	5* (FV/V _o)	10* (FV/V _o)	20* (FV/V _o)	50* (FV/V _o)	100* (FV/V _o)	200* (FV/V _o)	500* (FV/V _o)	1000* (FV/V _o)	2000* (FV/V _o)
DAI	<u>1X</u>	<u>5X</u>	<u>10X</u>	<u>20X</u>	<u>50X</u>	<u>100X</u>	<u>200X</u>	<u>500X</u>	1000X	<u>2000X</u>
SAMPLE (uL)	700	140	70	35	14	7	14	5.6	2.8	1.4
SUR (uL)	25	25	25	25	25	25	100	100	100	100
MeOH (uL)	275	275	275	275	275	275	1100	1100	1100	1100
Water (uL)	0	560	630	665	686	693	2786	2794.4	2797.2	2798.6
TOTAL (uL)	1000	1000	1000	1000	1000	1000	4000	4000	4000	4000
CF calc	1/.7	1/.14	1/.07	1/.035	1/.014	1/.007	4/.014	4/.0056	4/.0028	4/.0014
ID Solid	<u>1X</u>	<u>5X</u>	<u>10X</u>	<u>20X</u>	<u>50X</u>	<u>100X</u>	<u>200X</u>	<u>500X</u>	<u>1000X</u>	<u>2000X</u>
EXTRACT (uL)	182	200	100	50	20	10	20	8	4	2
IS (uL)	10	50	50	50	50	50	200	200	200	200
SUR (uL)	0	40	45	47.5	49	49.5	199	199.6	199.8	199.9
MeOH (uL)	8	674	769	816.5	845	854.5	3437	3448	3452	3454
WATER (uL)	0	36	36	36	36	36	144	144	144	144
TOTAL (uL)	200	1000	1000	1000	1000	1000	4000	3999.6	3999.8	3999.9
CF calc	((V _E /(M*S))/ 0.91)/1000	((V _E /(M*S))/ 0.2)/1000	((V _E /(M*S))/ 0.1)/1000	((V _E /(M*S))/ 0.05)/1000	((V _E /(M*S))/ 0.02)/1000	((V _E /(M*S))/ 0.01)/1000	((V _E /(M*S))/ 0.005)/1000	((V _E / (M*S))/ 0.002)/1000	((V _E / (M*S))/ 0.001)/1000	((V _E / (M*S))/ 0.0005)/1000

NOTE: Dilutions of 100x or below will be prepped in 1-mL FV; dilutions higher than 100x and will be prepped in 4-mL FV.

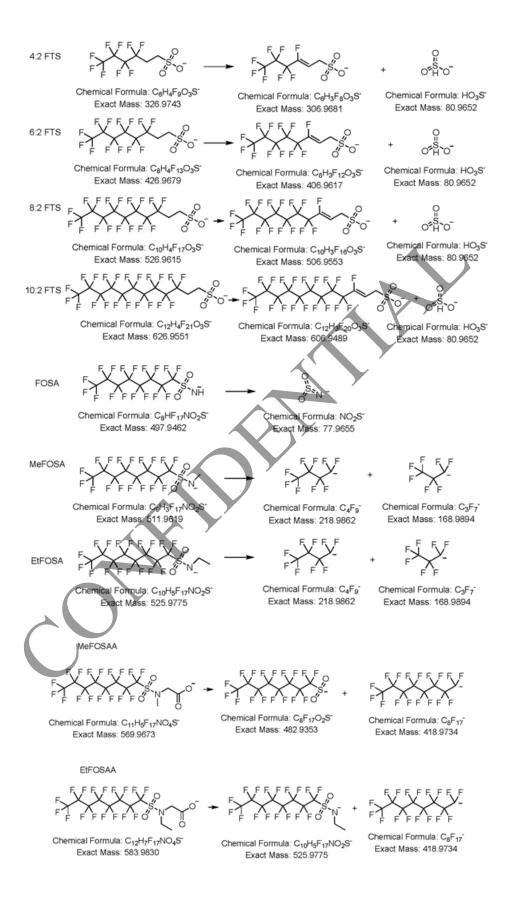
Appendix E: Chemical Derivation of Ion Transitions







emical Formula: FO₃S



Appendix F. DOD QSM Requirements

Sections found in this appendix replace and/or supplement the existing sections of the SOP. These requirements must be met when analyzing samples for the Department of Defense, as stipulated in the DOD Quality System Manual Version 5.1.1, Table B-15, 2018.

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Aqueous Sample Preparation	Each sample and associated batch QC samples.	Solid Phase Extraction (SPE) must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable. Samples of known high PFAS concentrations can be prepared by serial dilution instead of SPE, with documented project approval.	NA.	NA.	NA.
Soil and Sediment Sample Preparation	Each sample and associated batch QC samples.	Entire sample received by the laboratory must be homogenized prior to subsampling.	NA.	NA.	NA.
Sample Cleanup Procedure using ENVI-Carb™ or equivalent	Each sample and associated batch QC samples. Not applicable to AFFF formulation samples.	Removal of interferences from matrix.	NA.	Flagging is not appropriate.	Cleanup should reduce bias from matrix background.

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water

`	•			J	J		
QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments		
Mass Calibration	Initially prior to use and after performing major maintenance, as required to maintain documented instrument sensitivity and stability performance.	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Entire range needs to be mass calibrated.	NA.	Flagging is not appropriate.	NA.		
Tune Check	When the masses fall outside of the ±0.5 amu of the true value (as determined by the product ion formulas).	Mass assignments of tuning standard within 0.5 amu of true value.	Retune instrument and verify. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tune check repeated.	Flagging is not appropriate.	No samples shall be analyzed without a valid tune.		
Mass Spectral Acquisition Rate	Each analyte, Extracted Internal Standard Analyte, and Injection Internal Standard Analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	NA.	Flagging is not appropriate.	NA.		

Shealy Environmental Services, Inc.

Page 53 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

isomer only for that analyte (e.g., PFOA).

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water QC Check Minimum Frequency **Corrective Action** Flagging Criteria Acceptance Criteria Comments Calibration, All analytes. Standards containing NA. Flagging is not Standards containing both branched and linear appropriate. Calibration both branched and linear Verification, and isomers must be used isomers are to be used **Spiking Standards** when commercially during method validation available. to ensure the total response is quantitated for that analyte. If not available, the total response of the analyte must be integrated (i.e., Technical grade accounting for peaks that standards cannot be are identified as linear used for quantitative and branched isomers) analysis. and quantitated using a calibration curve which includes the linear

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass S	Spectrometry
(LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking W	/ater

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
QC Check on Transitions (Parent-> Product)	Prior to method implementation.	The chemical derivation of the ion transitions, both those used for quantitation and those used for confirmation, must be documented. Two transitions and the ion transition ratio per analyte shall be monitored and documented with the exception of PFBA and PFPeA. In order to avoid biasing results high due to known interferences for some transitions, the	NA.	Flagging Criteria Flagging is not appropriate.	NA.
		following transitions must be used for the quantification of the following analytes: PFOA: 413 —> 369 PFOS: 499 —> 80			
		PFHxS: 399 —> 80 PFBS: 299 —> 80 4:2 FTS: 327 —> 307			
		(continued next page)			

Shealy Environmental Services, Inc.

Page 55 of 69
Document Number: ME00213-08

Effective Date: 6/20/2018

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
on Transitions		6:2 FTS: 427> 407		A .	
Parent-> Product)		8:2 FTS: 527> 507			
(Continued)		NEtFOSAA: 584> 419			
		NMeFOSAA: 570 —>			
		419			
		If these transitions are			
		not used, the reason			
		must be technically	$\langle \lambda \rangle \rangle$		
		justified and documented			
		(e.g., alternate transition	Y		
		was used due to			
		observed interferences).			

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water						
QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments	
Initial Calibration (ICAL)	At instrument set-up and after ICV or CCV failure, prior to sample analysis.	The isotopically labeled analog of an analyte (Extracted Internal Standard Analyte) must be used for quantitation if commercially available (Isotope Dilution Quantitation). If a labeled analog is not commercially available, the Extracted Internal Standard Analyte with the closest retention time to the analyte must be used for quantitation. (Internal Standard Quantitation) S/N Ratio: ≥ 10:1 for all ions used for quantification. For analytes having a promulgated standard, (e.g., HA levels for PFOA and PFOS), the qualitative (confirmation) transition ion must have a S/N Ratio of ≥ 3:1. (continued next page)	Correct problem, then repeat ICAL.	Flagging is not appropriate.	No samples shall be analyzed until ICAL has passed. Isotope Dilution or Internal Standard Calibration is required for all analytes. External Calibration is not allowed. Calibration can be linear (minimum of 5 standards) or quadratic (minimum of 6 standards); weighting is allowed.	

Shealy Environmental Services, Inc.

Page 57 of 69
Document Number: ME00213-08

Effective Date: 6/20/2018

Table B-15. Per- and Polyfluoroalkyl Substances (P	PFAS) Using Liquid Chromatography Tandem Mass Spectrometry
(LC/MS/MS) With Isotope Dilution or Internal Standa	ard Quantification in Matrices Other Than Drinking Water

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Initial Calibration		The %RSD of the RFs			
(ICAL)		for all analytes must be			
(Continued)		<20%. Linear or non-			
		linear calibrations must			
		have $r^2 \ge 0.99$ for each			
		analyte. Analytes must			
		be within 70-130% of			
		their true value for each			
		calibration standard.			

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Instrument Sensitivity Check (ISC)	Prior to analysis and at least once every 12 hours.	Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values.	Correct problem, rerun ISC. If problem persists, repeat ICAL.	Flagging is not appropriate.	No samples shall be analyzed until ISC has met acceptance criteria. ISC can serve as the initial daily CCV.
Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Analyte concentrations must be within ±30% of their true value.	Correct problem, rerun ICV. If problem persists, repeat ICAL.	Flagging is not appropriate.	No samples shall be analyzed until calibration has been verified.
Continuing Calibration Verification (CCV)	Prior to sample analysis, after every 10 field samples, and at the end of the analytical sequence.	Concentration of analytes must range from the LOQ to the mid-level calibration concentration. Analyte concentrations must be within ±30% of their true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification.	Results may not be reported without valid CCVs. Instrument Sensitivity Check (ISC) can serve as a bracketing CCV.

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Instrument Blanks	Immediately following the highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte must be ≤ ½ the LOQ.	If acceptance criteria are not met after the highest calibration standard, calibration must be performed using a lower concentration for the highest standard until acceptance criteria are not met after the highest standard which is not included in the calibration, the standard cannot be used to determine the highest concentration in samples at which carryover does not occur. If acceptance criteria are not met after sample, additional instrument blanks must be analyzed until acceptance criteria are met. Additional samples shall not be analyzed until acceptance	Flagging is only appropriate in cases when the sample cannot be reanalyzed and when there is no more sample left.	Note: Successful analysis following the highest standard analyzed determines the highest concentration that carryover does not occur. The highest standard analyzed may be analyzed as part of the calibration curve or following the calibration curve, if analyzed following the calibration curve, it is not used to extend out the calibration range. It is used only to document a higher concentration at which carryover still does not occur. If sample concentrations exceed this range and the sample(s) following exceed this acceptance criteria (>1/2 LOQ), they must be reanalyzed.

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Extracted Internal Standard Analytes	Every field sample, standard, blank, and QC sample.	Added to sample prior to extraction. For aqueous samples prepared by serial dilution instead of SPE, added to samples prior to analysis. Extracted Internal Standard Analyte recoveries must be within 50% to150% of the true value.	If recoveries are acceptable for QC samples, but not field samples, the field samples must be reprepped and reanalyzed (greater dilution may be needed). If recoveries are unacceptable for QC samples, correct problem, and reanalyze all associated failed field samples.	Apply Q-flag and discuss in the Case Narrative only if reanalysis confirms failures in exactly the same manner.	Failing analytes shall be thoroughly documented in the Case Narrative.

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Injection Internal Standard Analytes	Every field sample, standard, blank, and QC sample.	Added to aliquot of sample dilutions, QC samples, and standards just prior to analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not performed, the peak areas must be within -50% to +50% of the peak area measured in daily initial CCV.	If peak areas are unacceptable, analyze a second aliquot of the extract or sample if enough extract remains. If there is not enough extract, reanalyze the first aliquot. If second analysis meets acceptance criteria, report the second analysis. If it fails, either analysis may be reported with the appropriate flags.	Apply Q-flag and discuss in the Case Narrative.	Alternative Injection Internal Standard Analytes are recommended when there is obvious chromatographic interference.

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water QC Check Minimum Frequency Acceptance Criteria **Corrective Action** Flagging Criteria Comments Method Blank One per preparatory No analytes detected > Correct problem. If If reanalysis cannot be Results may not be 1/2 LOQ or > 1/10th the performed, data must be required, reprep and reported without a valid (MB) batch. amount measured in any reanalyze MB and all QC qualified and explained in MB. sample or 1/10th the samples and field samples the Case Narrative. regulatory limit, processed with the Flagging is only contaminated blank. whichever is greater. Apply B-flag to all results appropriate in cases for the specific analyte(s) where the samples in all samples in the cannot be reanalyzed. associated preparatory batch. Laboratory Blank spiked with all Correct problem, then re-Results may not be One per preparatory If reanalysis cannot be **Control Sample** reported without a valid batch. analytes at a prep and reanalyze the performed, data must be (LCS) concentration ≥ LOQ and LCS and all samples in qualified and explained in LCS. ≤ the mid-level the associated the Case Narrative calibration concentration. preparatory batch for Flagging is only failed analytes if sufficient Apply Q-flag to specific appropriate in cases sample material is Use in-house LCS limits analyte(s) in all samples in where the samples available. if project limits are not the associated cannot be reanalyzed. specified. preparatory batch.

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry
(LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Matrix Spike	One per preparatory batch. Not required for aqueous samples prepared by serial dilution instead of SPE.	Sample spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. Use in-house LCS limits if project limits are not specified.	Examine the project- specific requirements. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.	For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference (i.e., matrix effect or analytical error).

	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
For MSD: One per preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE.	For MSD: Sample spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. For MSD: Use in-house LCS limits if project limits are not specified.	Examine the project- specific requirements. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.	The data shall be evaluated to determine the source of difference For Sample/MD: RPD criteria only apply to analytes whose concentration in the sample is greater than dequal to the LOQ.
	RPD ≤ 30% (between MS and MSD or sample and MD).			The MD is a second aliquot of the field sample that has been prepared by serial dilution.
Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of " <loq" analyte(s).<="" for="" td=""><td>Spike aliquot(s) of sample at the final dilution(s) reported for sample with all analytes that have reported value of "<loq" "<loq"="" (the="" at="" be="" concentration="" dilution.="" final="" in="" loq="" must="" reported="" sample="" spike="" td="" the="" to="" value).<="" with=""><td>When analyte concentrations are calculated as "<loq," 70-130%="" acceptance="" and="" at="" be="" consecutively="" criteria="" criteria,="" dilutions="" does="" duplicate,="" higher="" is="" meet="" met.<="" must="" not="" post="" reanalyzed="" recovery="" sample="" sample,="" spike="" td="" the="" until=""><td>Flagging is not appropriate.</td><td>When analyte concentrations are calculated as "<loq," acceptable="" be="" may="" not="" post="" recoveries.<="" reported="" results="" spike="" td="" without=""></loq,"></td></loq,"></td></loq"></td></loq">	Spike aliquot(s) of sample at the final dilution(s) reported for sample with all analytes that have reported value of " <loq" "<loq"="" (the="" at="" be="" concentration="" dilution.="" final="" in="" loq="" must="" reported="" sample="" spike="" td="" the="" to="" value).<="" with=""><td>When analyte concentrations are calculated as "<loq," 70-130%="" acceptance="" and="" at="" be="" consecutively="" criteria="" criteria,="" dilutions="" does="" duplicate,="" higher="" is="" meet="" met.<="" must="" not="" post="" reanalyzed="" recovery="" sample="" sample,="" spike="" td="" the="" until=""><td>Flagging is not appropriate.</td><td>When analyte concentrations are calculated as "<loq," acceptable="" be="" may="" not="" post="" recoveries.<="" reported="" results="" spike="" td="" without=""></loq,"></td></loq,"></td></loq">	When analyte concentrations are calculated as " <loq," 70-130%="" acceptance="" and="" at="" be="" consecutively="" criteria="" criteria,="" dilutions="" does="" duplicate,="" higher="" is="" meet="" met.<="" must="" not="" post="" reanalyzed="" recovery="" sample="" sample,="" spike="" td="" the="" until=""><td>Flagging is not appropriate.</td><td>When analyte concentrations are calculated as "<loq," acceptable="" be="" may="" not="" post="" recoveries.<="" reported="" results="" spike="" td="" without=""></loq,"></td></loq,">	Flagging is not appropriate.	When analyte concentrations are calculated as " <loq," acceptable="" be="" may="" not="" post="" recoveries.<="" reported="" results="" spike="" td="" without=""></loq,">
	preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of " <loq" for<="" td=""><td>preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE. For MSD: Use in-house LCS limits if project limits are not specified. RPD ≤ 30% (between MS and MSD or sample and MD). Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of "<loq" "<loq"="" aliquot(s)="" all="" analyte(s).="" analytes="" at="" be="" concentration="" dilution(s)="" dilution.="" final="" for="" have="" in="" loq="" must="" of="" reported="" sample="" sample<="" spike="" td="" that="" the="" to="" value="" with=""><td>preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE. For MSD: Use in-house LCS limits if project limits are not specified. RPD ≤ 30% (between MS and MSD or sample and MD). Spike aliquot(s) of sample and MD). Spike aliquot(s) of sample are the final dilution instead of SPE that have reported value of "<loq" "<loq"="" "<loq,"="" (the="" 70-130%="" acceptance="" aliquot(s)="" analyte="" analyte(s).="" and="" are="" as="" at="" be="" calculated="" concentration="" concentrations="" consecutively="" criteria="" criteria,="" dilution.="" dilutions="" does="" duplicate,="" final="" for="" higher="" is="" loq="" meet="" met.<="" must="" not="" of="" post="" reanalyzed="" recovery="" reported="" sample="" sample,="" spike="" td="" the="" to="" until="" value).="" when="" with=""><td>with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. For MD: Each aqueous sample prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of "<loq" "<loq"="" "<loq,"="" (the="" 70-130%="" a="" acceptance="" additional="" aliquot(s)="" all="" analyte="" analyte(s).="" analytes="" and="" are="" as="" at="" be="" calculated="" calibration="" client="" concentration="" concentration.="" concentrations="" contact="" criteria,="" dilution.="" does="" duplicate,="" duplicate,<="" final="" for="" loq="" measures="" meet="" mid-level="" must="" not="" of="" post="" recovery="" reported="" requirements.="" sample="" specific="" spike="" taken.="" td="" the="" to="" value).="" when="" with="" ≤="" ≥=""></loq"></td></loq"></td></loq"></td></loq">	preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE. For MSD: Use in-house LCS limits if project limits are not specified. RPD ≤ 30% (between MS and MSD or sample and MD). Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of " <loq" "<loq"="" aliquot(s)="" all="" analyte(s).="" analytes="" at="" be="" concentration="" dilution(s)="" dilution.="" final="" for="" have="" in="" loq="" must="" of="" reported="" sample="" sample<="" spike="" td="" that="" the="" to="" value="" with=""><td>preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE. For MSD: Use in-house LCS limits if project limits are not specified. RPD ≤ 30% (between MS and MSD or sample and MD). Spike aliquot(s) of sample and MD). Spike aliquot(s) of sample are the final dilution instead of SPE that have reported value of "<loq" "<loq"="" "<loq,"="" (the="" 70-130%="" acceptance="" aliquot(s)="" analyte="" analyte(s).="" and="" are="" as="" at="" be="" calculated="" concentration="" concentrations="" consecutively="" criteria="" criteria,="" dilution.="" dilutions="" does="" duplicate,="" final="" for="" higher="" is="" loq="" meet="" met.<="" must="" not="" of="" post="" reanalyzed="" recovery="" reported="" sample="" sample,="" spike="" td="" the="" to="" until="" value).="" when="" with=""><td>with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. For MD: Each aqueous sample prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of "<loq" "<loq"="" "<loq,"="" (the="" 70-130%="" a="" acceptance="" additional="" aliquot(s)="" all="" analyte="" analyte(s).="" analytes="" and="" are="" as="" at="" be="" calculated="" calibration="" client="" concentration="" concentration.="" concentrations="" contact="" criteria,="" dilution.="" does="" duplicate,="" duplicate,<="" final="" for="" loq="" measures="" meet="" mid-level="" must="" not="" of="" post="" recovery="" reported="" requirements.="" sample="" specific="" spike="" taken.="" td="" the="" to="" value).="" when="" with="" ≤="" ≥=""></loq"></td></loq"></td></loq">	preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE. For MSD: Use in-house LCS limits if project limits are not specified. RPD ≤ 30% (between MS and MSD or sample and MD). Spike aliquot(s) of sample and MD). Spike aliquot(s) of sample are the final dilution instead of SPE that have reported value of " <loq" "<loq"="" "<loq,"="" (the="" 70-130%="" acceptance="" aliquot(s)="" analyte="" analyte(s).="" and="" are="" as="" at="" be="" calculated="" concentration="" concentrations="" consecutively="" criteria="" criteria,="" dilution.="" dilutions="" does="" duplicate,="" final="" for="" higher="" is="" loq="" meet="" met.<="" must="" not="" of="" post="" reanalyzed="" recovery="" reported="" sample="" sample,="" spike="" td="" the="" to="" until="" value).="" when="" with=""><td>with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. For MD: Each aqueous sample prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of "<loq" "<loq"="" "<loq,"="" (the="" 70-130%="" a="" acceptance="" additional="" aliquot(s)="" all="" analyte="" analyte(s).="" analytes="" and="" are="" as="" at="" be="" calculated="" calibration="" client="" concentration="" concentration.="" concentrations="" contact="" criteria,="" dilution.="" does="" duplicate,="" duplicate,<="" final="" for="" loq="" measures="" meet="" mid-level="" must="" not="" of="" post="" recovery="" reported="" requirements.="" sample="" specific="" spike="" taken.="" td="" the="" to="" value).="" when="" with="" ≤="" ≥=""></loq"></td></loq">	with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. For MD: Each aqueous sample prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE. Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of " <loq" "<loq"="" "<loq,"="" (the="" 70-130%="" a="" acceptance="" additional="" aliquot(s)="" all="" analyte="" analyte(s).="" analytes="" and="" are="" as="" at="" be="" calculated="" calibration="" client="" concentration="" concentration.="" concentrations="" contact="" criteria,="" dilution.="" does="" duplicate,="" duplicate,<="" final="" for="" loq="" measures="" meet="" mid-level="" must="" not="" of="" post="" recovery="" reported="" requirements.="" sample="" specific="" spike="" taken.="" td="" the="" to="" value).="" when="" with="" ≤="" ≥=""></loq">

Table B-15. Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrome	etry
(LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water	

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
		the spike must recover			
		within 70-130% of its true			
		value.			
				·	
			, ,		
			/		

Effective Date: 6/20/2018

Page 66 of 69

REVISION HISTORY

ME00213-01

-New Document

Rev 01 to Rev 02

- -Section 1.1 Updated to include 537 MOD ID solids; added that modified methods are addressed in the appendices
- -Section 2.1 Added SPE cartridge: Strata-XL; updated amount of methanol from "small amount" to "8 mL"
- -Section 2.2 Corrected SPE cartridge from SDVB to Strata-XL-AW; added SPE-Envi-Carb tube filtration
- -Section 2.3 Added final sample volume = 1 mL; added that no extraction is required
- -Section 2.4 Updated terminology from "internal standards" to "extraction standards"; elaborated on the filtration using SPE-Envi-Carb tubes
- -Section 3.5 Added surrogate; added Note
- -Section 3.13 Deleted LOQ; Added minimum reporting level
- -Section 3.17 Deleted surrogate moved to section 3.5
- -Sections 6.1 Updated 250mL bottle item #; added bottle info for solids
- -Section 6.3 Added conical tube catalog #
- -Section 6.9.1 Added Strata-XL-AW cartridge info
- -Section 6.9.2 Deleted Strata-XL-AW cartridge info; moved to section 6.9.1
- -Sections 6.14 through 6.17 Added shaker, centrifuge, sonicator, ottawa sand
- -Section 7.1.6 Corrected pH of buffer from 4 to 7
- -Section 7.2.1.1 Changed stability of IS standard from 6 months to 12
- -Section 7.2.2.2 Changed "ES" to "EIS"; Deleted: "This solution is used to spike samples and all of the QC."; added 13C2-PFHxA to table
- -Section 7.2.2.3 Changed "ES" to "SUR/EIS" and added: "This solution is used to spike samples and all of the QC."
- -Sections 7.2.2.4 and 7.2.5 Changed "ES" to "SUR/EIS"
- -Section 7.2.4 Added stability of 6 months when stored at 2 6 C; Changed "ES" to "SUR/EIS"
- -Sections 7.2.6 & 7.2.7 Added instrument blank and method blank
- -Section 7.2.6.2 Deleted LOQ level used as ISC for all methods
- -Section 7.2.8 Updated concentrations used for 537 MOD ID for CCV/CCC/ISC; changed ICAL high standard from 5000 to 10000ppt; added: "Analyte concentrations must be within 4/-30% of their true values."
- -Sections 7.2.9 & 7.2.9.1 through 7.2.9.3 Updated/added prep of LCS/LFB
- -Sections 7.2.10 & 7.2.10.1 through 7.2.10.3 Updated/added prep of MS/MSD -Sections 7.2.11 & 7.2.11.1 through 7.2.11.3 Updated/added prep of MDL
- -Sections 7.2.12, 7.2.12.1, 7.2.12.3 Updated/added prep of DOC
- -Section 8.1.3 Changed soil container from glass to polypropylene
- -Section 9.3 Added instrument blank
- -Section 9.11 Added: "This requirement only applies to Method 537, not the modified methods."
- -Section 10.2.1 Added that mass calibration/mass tune will be performed after major maintenance
- -Section 11.2.4 Changed "MeOH" to "reagent water"
- -Section 11.2.20 Updated type of container used to store extract
- -Section 11.3 Added procedure for analyzing samples
- -Section 12.2.1 Updated calculation
- -Section 12.2.3 Added: "from the ICAL linear regression"
- -Section 12.4 Added: "If a dilution of the extract is required, fortification of the diluted extract is necessary."
- -Section 12.5 Clarified that linear and branched isomers are integrated together and summed; added: "Purchased standards contain both linear and branched isomers; therefore, individual ICALs for the linear and branched isomers will not be possible."
- -Sections 16.1, 16.2 Updated references to 537 and QSM
- -Sections 16.3, 16.4 Added references to ISO 25101:2009(E) and method 8321B
- -Table 1 Added soils; added CAS #s; added footnote abouit CAS #s
- -Table 2-B Added CAS #s; added footnote about CAS #s
- -Table 2-D Added table for 537 MOD ID solids
- -Tables 3-B, 4-A, 5-A Added "Aqueous and Solids" to title
- -Appendix B Added Note
- -App B Section 2.4 Changed from rinsing the SPE to wetting rim to ensure proper seal
- -Appendix D Added sections 3, 7, 8, 14, 15; Updated section 5
- -Appendix E Added appendix describing 537 MOD ID for solids

Shealy Environmental Services, Inc. Page 67 of 69 Document Number: ME00213-08 Effective Date: 6/20/2018

Many changes were made as per DoD comments on this SOP

- -Replaced "ES" and "EIS" with "surrogate" or "SUR" or deleted references to "ES" or "EIS" where needed throughout the document in order to clarify names of standards
- -Section 2.3 Added: "Method 537 MOD DS does not comply with QSM 5.1 Table B-15 requirements and as such can only be used for screening DoD/DOE samples." in order to clarify the purpose of this method as it pertains to DoD/DOE
- -Section 2.4 Added: "An aliquot of the extract is fortified with internal standards (IS)." because the IS was missing from the general statement about the method.
- -Section 3.5 Deleted section on EIS/SUR and added two sections on IS and SUR to align with new standard naming scheme
- -Section 6 Replaced reference to polypropylene containers for HDPE; deleted that other materials can be substituted; deleted reference to the use of an automated extraction system since none is used currently; added "microcentrifuge tubes"
- -Sections 6.1, 6.2 & 7.2 Updated containers where needed to HDPE, updated list of containers for clarity
- -Section 7.2 Added: "standards purchased from Wellington are >98%" to clarify that standards used of higher purity than method 537 requires; added note stating MOD methods are located in the appendices for clarity
- -Sections 7.2.1, 7.2.3.1 Deleted: "See the appendices for the applicable internal standards used in the MOD methods." since this notice has been added as a note in section 7.2; added note concerning 537 IS compounds
- -Sections 7.2.1.1, 7.2.2.1 Deleted: "as individual stock standard solutions" since not all solutions contain individual analytes; added: "after opening"
- -Sections 7.2.3.1 Clarified location of the analyte list and concentrations
- -Sections 7.2.3.1.1 through 7.2.3.1.3 Added PDS standard preparation instructions for clarity.
- -Sections 7.2.3.1.4 & 7.2.3.1.5 Moved to 7.2.5.1 and 7.2.5.2 and added standard preparation instructions for clarity
- -Added: "for a concentration of" and "on column concentration" to each location where a final or on column concentration is listed throughout the document for clarity; also added final concentrations where on column concentrations were already listed for
- -Sections 8.1.1 through 8.1.3 Modified bottle types, separated methods into different sections
- -Section 9.3 Added that 2 instrument blanks and ICAL standards are analyzed; added that this is done to check for carryover; changed limit from < 1/2 LOQ to < 1/3 LOQ
- -Section 9.5 Added that the LCS may be should be reanalyzed if the failure is due to the instrument and also that if the failure is due to a poor extraction, the entire batch must be re-extracted.
- -Section 10.5 Clarified calculation of DF
- -Section 12.2.3 Corrected "calibration standard" to "sample"
- -Section 13.2.1.5 Deleted instructions to see section 10.2.4.1
- -Section 16.2 Added month of publication to the QSM reference for clarity
- -Table 5A Clarified list of compounds found in the SUR and IS for each method; Added that the 5000 and 10000 pg/mL levels are prepared using the 50X PDS mix
- -Table 6 Added table containing DL, LOD, LOQ
- -Appendices Moved 537 MOD ID (Solids) appendix E to appendix C
- -Appendix B 537 MOD ID (Aqueous)
 -Section 1.1.1 Added section describing the stock solutions used for prepping the IS and the storage conditions for clarity
- -Section 1.2 Added section describing the stock solutions used for prepping the SUR for clarity
- -Section 1.3 Added section describing the analyte PDS in order to define how these are prepped
- -Sections 1.6 through 1.14 Moved sections (ICV, instrument blank, MB, CCV, LCS, MS, MDL, IDOC) from the main body of the SOP (section 7) to the appropriate appendix in order to keep all instructions specific to each MOD method within the appendices
- -Section 2.25 Clarified the definition of DF
- -Appendix C 537 MOD ID (Solids)
- -Section 1.7 Added section describing the analyte PDS in order to define how these are prepped
- -Section 1.8 Added section describing what standards to use for preparing the ICAL for clarity
- -Sections 1.10 through 1.17 Moved sections (ICV, instrument blank, MB, CCV, LCS, MS, MDL, IDOC) from the main body of the SOP (section 7) to the appropriate appendix in order to keep all instructions specific to each MOD method within the appendices
- -Appendix D 537 MOD DS
- -Added note stating that the 537 MOD DS method does not comply with QSM 5.1 table B-15 in order to clarify the use of this method for DoD/DOE
- -Section 1.3 Added section describing the analyte PDS in order to define how these are prepped
- -Sections 1.6 through 1.13 Moved sections (ICV, instrument blank, MB, CCV, LCS, MS, MDL, IDOC) from the main body of the SOP (section 7) to the appropriate appendix in order to keep all instructions specific to each MOD method within the appendices
- -Section 2.8 Clarified the definition of DF
- -Appendix E DoD

Shealy Environmental Services, Inc.

Page 68 of 69

Document Number: ME00213-08

Effective Date: 6/20/2018

- -Corrected QSM reference from Nov 2016 to Jan 2017
- -Replaced entire appendix with tables from QSM 5.1 Table B-15

Rev 03 to Rev 04

-Appendix F - Inserted appendix showing the chemical derivations of the ion transitions

Rev 04 to Rev 05 Effective Date: 11/22/2017

- -Removed all references to EPA Method 537 (for drinking water) and our in-house modified dilute and shoot (direct aqueous injection) methods to that each of these methods are in separate SOPs
- -Section 1.2 updated to refer directly to B-15 and reference the appendix containing the table
- -Section 2.1 Updated the solution used to elute samples
- -Section 2.2 Added: "See Appendix B for specific procedures for preparing and analyzing solid samples by 537 MOD ID."
- -Section 2.3 Added section on serial dilution for AFFF pure product formulation analysis
- -Section 3.7 Added limit of detection
- -Section 3.8 Updated limit of quantitation section
- -Section 3.15 Updated MDL section to reflect MUR2017 definition
- -Section 4.2 Changed requirement for supplies and equipment from less than 1/2 MDL to less than 1/2 LQC
- -Section 6.85 Added SPE adapter caps
- -Section 6.9 Deleted extract concentration system
- -Section 6.10.6 Added guard cartridge
- -Section 7.2.1 Added note concerning location of list of compounds
- -Section 7.2.4 Updated pds solution preparations
- -Section 7.2.5 Updated ICAL standard preparations
- -Section 7.4 Updated ICV preparation
- -Section 7.14 Corrected pds mix concentration
- -Section 9.4 Added section on LOD/LOQ verification
- -Section 10.2.3.2 Added to use the PFAS IS-SUR suppression check form
- -Section 11.2.11 Added: "(assuming 1g/mL density). '
- -Section 11.2.12 Added: "Once entire sample has passed through the SPE cartridge,...."
- -Appendix C Aqueous serial dilution Added appendix

Rev 05 to Rev 06 Effective Date: 04/16/2018

- -Section 6.8.6: Added vacuum tubing to Equipment and Supplies list
- -Section 7.1.5: Updated ammonia-methanol preparation procedures to reflect preparation at a larger final volume
- -Section 7.1.6: Updated ammonium acetate/acetic acid buffer preparation procedures to reflect preparation at a larger final volume
- -Section 7.2.2.3: Added preparation procedures for 100 ppb SUR mix
- -Section 7.2.4: Added GenX to analyte PDS solutions
- -Section 7.11: Updated concentration of CCV/ISC standards
- -Section 7.12: Updated concentration and spiking volume of LCS standard
- -Section 7.13: Updated concentration and spiking volume of MS/MD spike standard
- -Section 7.14: Updated concentration and spiking volume of MDL
- -Section 7.15: Updated concentration and spiking volume of IDOC/CDOC
- -Section 8.3: Updated solid sample holding time from 14 days to 28 days
- -Section 9.7: Updated LCS recovery criteria from 70-130% to 70-150%
- -Section 9.10: Updated MS criteria frequency to one sample per batch, "if provided by the client"; updated MS/MD recovery criteria from 70-130% to 70-150%
- -Section 9.11: Updated FD/MSD criteria frequency to one sample per batch, "if provided by the client"
- -Section 11.2.1: Updated spike volume and concentration of SUR mix
- -Section 11.2.6: Added information regarding corrective actions procedures that must occur if the SPE cartridge goes dry
- -Section 11.2.20: Added information regarding corrective actions procedures that must occur if the SPE cartridge goes dry
- -Section 12.2: Added reference to correction factors
- -Section 12.5: Added statement regarding limited availability of quantitative standards containing both linear and branched isomers
- -Section 12.6: Added integration procedures
- -Section 13.24: Added annual CDOC requirement
- -Section 15.1: Updated waste management section to reference the waste management plan

Rev 06 to Rev 07 Effective Date: 5/25/2018

-Section 7.2.4.1 - Corrected amounts of standards, total volume and amounts of methanol and water

Shealy Environmental Services, Inc.

Page 69 of 69

Document Number: ME00213-08

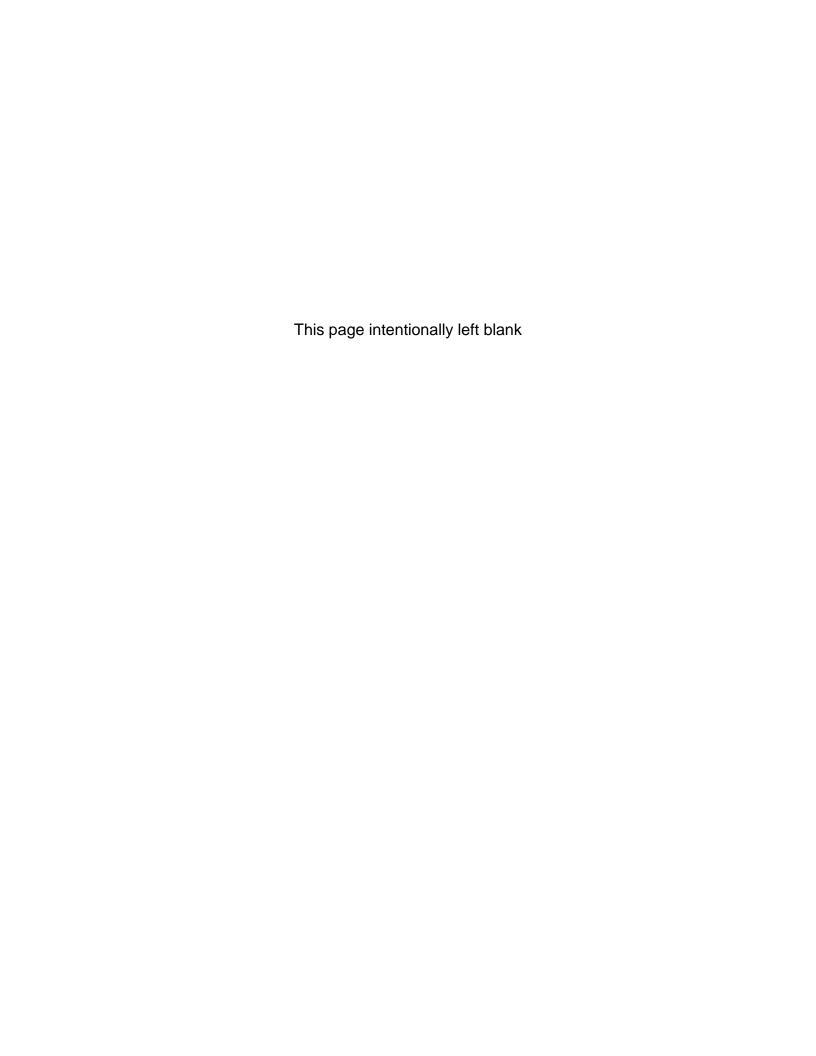
Effective Date: 6/20/2018

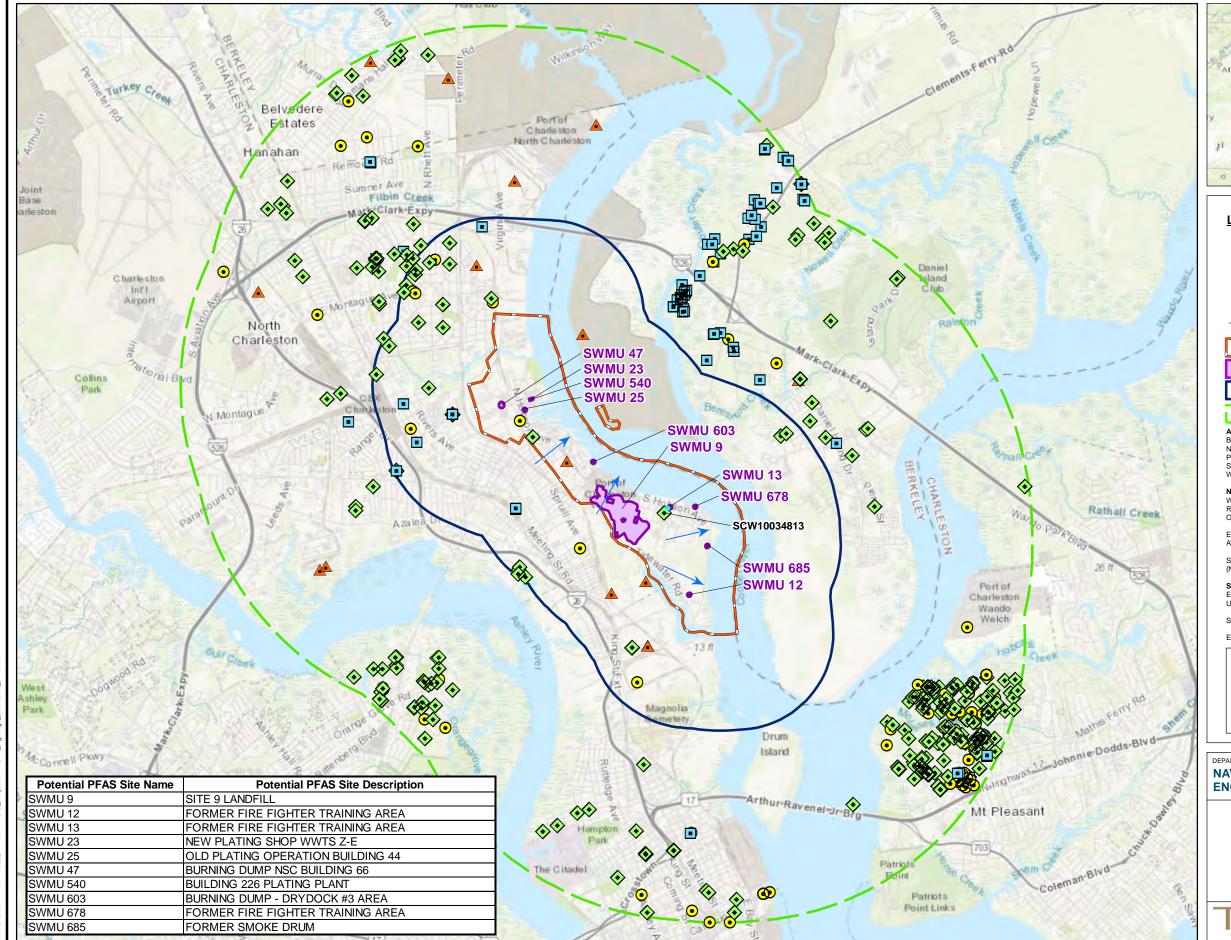
Rev 07 to Rev 08 Effective Date: 6/20/2018

- -Section 12.5 Added: "with each calibration event" as added instructions for the analysis of a technical standard
- -Tables 2A & 2B Deleted duplicate row containing PFDA information
- -Appendix B Section 1.8.1 Updated prep of 10X stock analyte PDS
- -Appendix B Section 1.17 Updated amount of and final concentration of 100X PDS mix used to prepare the soil MDL sample
- -Appendix B Section 1.18 Updated amount of and standard used to prepare the DOC sample
- -Appendix B Section 1.19 Added ammonia-methanol reagent
- -Appendix B Section 2.5 Updated amount of MeOH used and added "4 mL 0.3% Amm-MeOH"
- -Appendix D Updated "DF" to "CF" in the first column under ID Aq, DAI and ID Solid; Under ID Solid Updated all CF calculations



APPENDIX E FORMER CNC WELL SEARCHES MAP AND INFORMATION







LEGEND

WATER SUPPLY DOMESTIC

WATER SUPPLY IRRIGATION

WATER SUPPLY INDUSTRIAL

WATER SUPPLY - (EXISTING, UNKNOWN OR RECREATIONAL)

GENERAL SHALLOW GROUNDWATER FLOW DIRECTION

FORMER CHARLESTON NAVAL COMPLEX

POTENTIAL PFAS SITES

1 MILE BUFFER OF INSTALLATION

3 MILE BUFFER OF INSTALLATION

ABBREVIATIONS:
BRAC - BASE REALIGNMENT AND CLOSURE NSC - NAVAL STATION CHARLESTON PFAS - PERFLUOROALKYL SUBSTANCES SWMU - SOLID WASTE MANAGEMENT UNIT WWTS - WASTE WATER TREATMENT SYSTEM

WATER SUPPLY WELLS IDENTIFIED AS EXISTING, UNKNOWN OR RECREATIONAL ARE PROVIDED BY SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

ESTIMATED GROUNDWATER FLOW DIRECTION BASED ON AVAILABLE REPORT FOR INDIVIDUAL SITES

SOME POTENTIAL PFAS SITE BOUNDARIES ARE ENLARGED

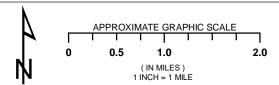
(NOT TO SCALE) FOR DISPLAY PURPOSES

SOURCES: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)

USA SPATIAL FEATURE CLASS AND RASTER IMAGE

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

ENVIRONMENTAL DATA RESOURCES INC. (EDR)



DEPARTMENT OF THE NAVY **NAVAL FACILITIES**

ENGINEERING COMMAND



WELL SEARCHES AROUND BASES WITH POTENTIAL PERFLUOROALKYL SUBSTANCE SITES AT VARIOUS BRAC INSTALLATIONS

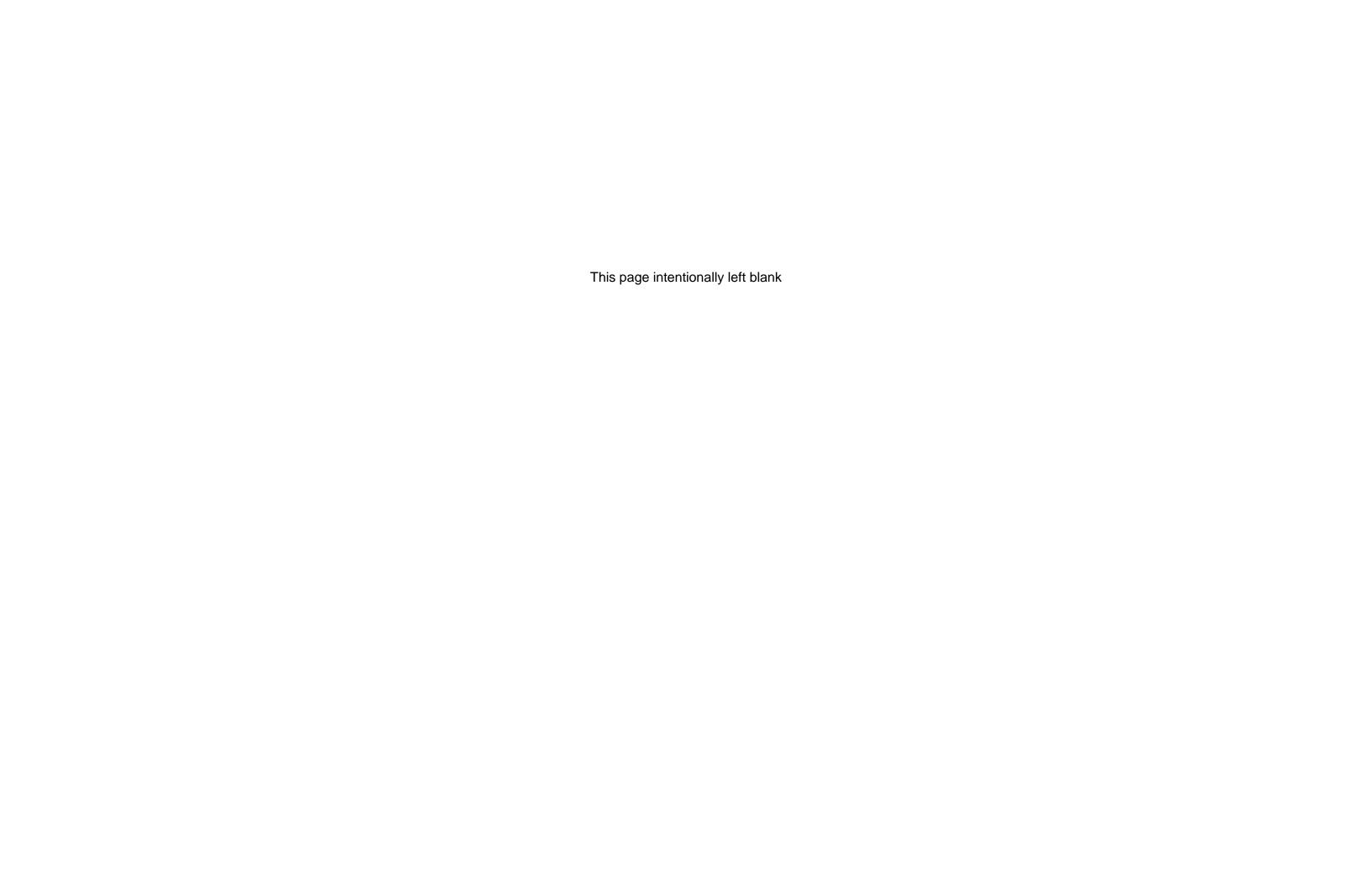
FIGURE 8

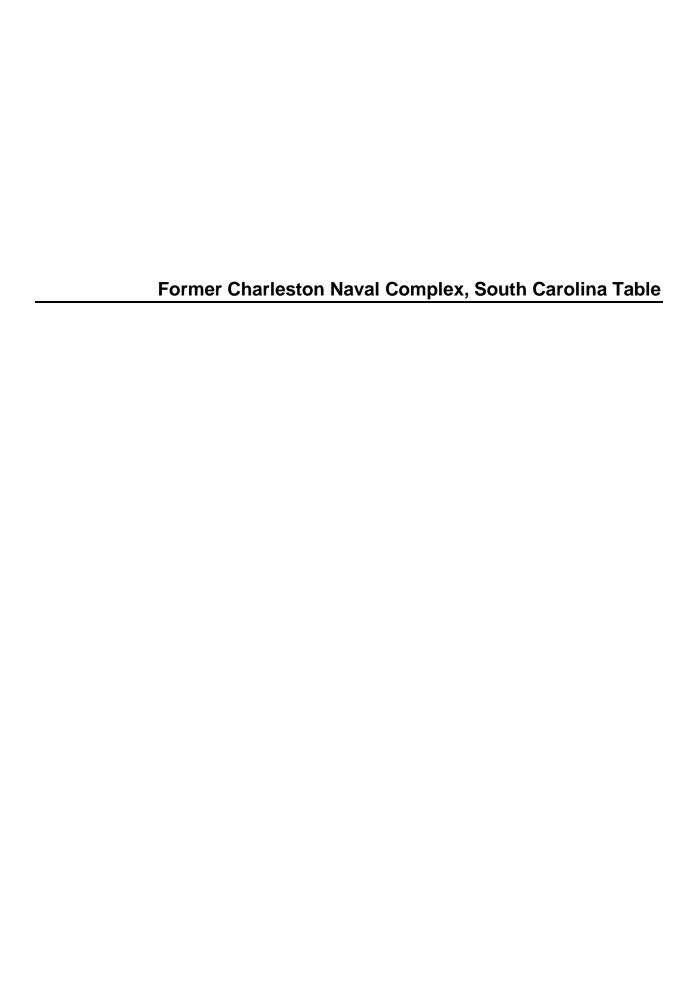
FORMER CHARLESTON NAVAL COMPLEX CHARLESTON, SOUTH CAROLINA



DATE: SEPTEMBER 2016

CONTRACT NO.: N62473-16-C-2019





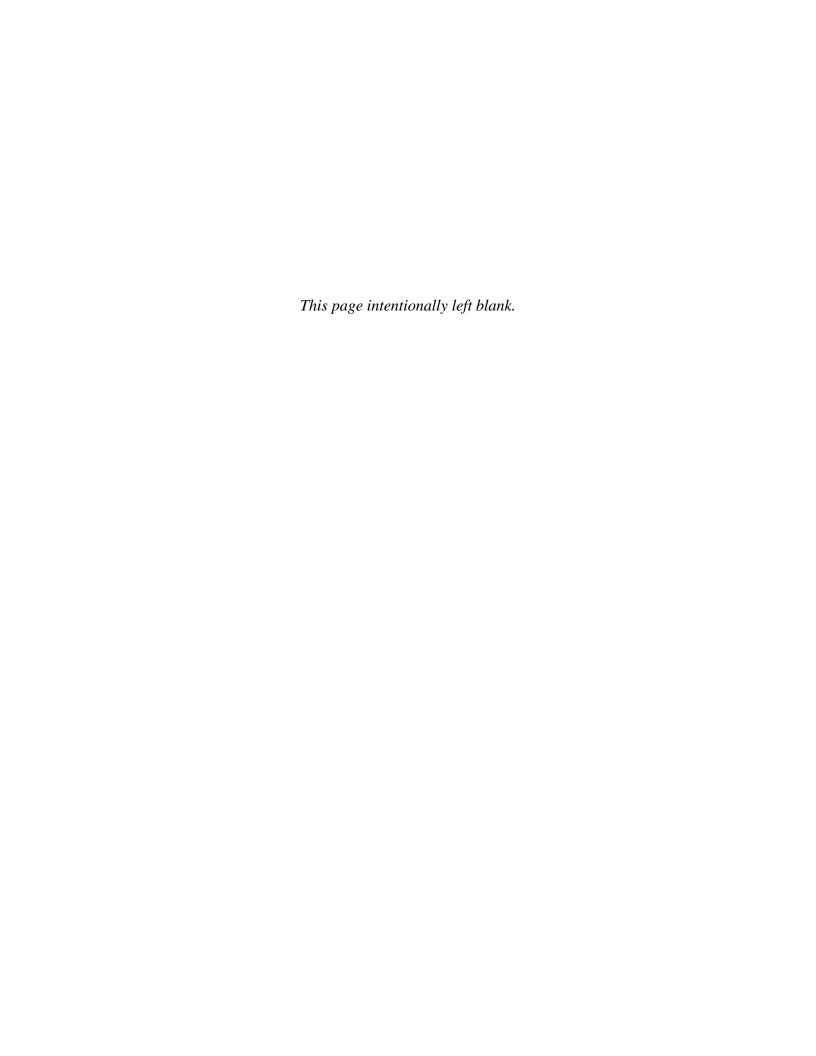


	Table 6: FO	rmer Charleston Na	ivai Complex, Sc	outh Carolina			1
						Groundwater	
				A ativa was an	1	protection	General
					Underlying	classification if	
		Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Industrial	CHN-639	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-609	Unknown	•	Unknown	Unknown	Unknown	See Figure 8
Recreational	CHN-294	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-540	Unknown	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	BRK-297	Unknown	0	Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-49	Unknown	515	Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-959	Unknown	330	Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-460	Unknown	0	Unknown	Unknown	Unknown	See Figure 8
Industrial	BRK-677	Unknown	342	Unknown	Unknown	Unknown	See Figure 8
Domestic	BRK-670	Unknown	300	Unknown	Unknown	Unknown	See Figure 8
	BRK-273	Unknown	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	BRK-694	Unknown	320	Unknown	Unknown	Unknown	See Figure 8
	BRK-641	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-476	Unknown		Unknown	Unknown	Unknown	See Figure 8
Domestic	BRK-290	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-2	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-108	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-107	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-607	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-610	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-541	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-582	Unknown		Unknown	Unknown	Unknown	See Figure 8
Industrial	CHN-583	Unknown	·	Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-136	Unknown		Unknown	Unknown	Unknown	See Figure 8
	CHN-136 CHN-115	Unknown		Unknown	Unknown	Unknown	See Figure 8
Recreational				Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-289	Unknown		Unknown	Unknown	Unknown	See Figure 8
11.1	CHN-292	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-87	Unknown		Unknown	+		·
Pubilc	CHN-167	Unknown			Unknown	Unknown	See Figure 8
Unknown	CHN-90	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-86	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-91	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-89	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-92	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-88	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-95	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-93	Unknown		Unknown	Unknown	Unknown	See Figure 8
Unknown	CHN-94	Unknown		Unknown	Unknown	Unknown	See Figure 8
Recreational	CHN-12	Unknown		Unknown	Unknown	Unknown	See Figure 8
	CHN-782	Unknown		Unknown	Unknown	Unknown	See Figure 8
	CHN-784	Unknown	0	Unknown	Unknown	Unknown	See Figure 8

	Table 6. For	mer Charleston Na	ivai Complex, 30	Julii Carollila	1		1	
				ļ		Groundwater		
					1	protection		
					Underlying	classification if	General	
		Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater	
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction	
	CHN-785	Unknown	0	Unknown	Unknown	Unknown	See Figure 8	
	CHN-783	Unknown		Unknown	Unknown	Unknown	See Figure 8	
Unknown	CHN-11	Unknown	0	Unknown	Unknown	Unknown	See Figure 8	
Unknown	CHN-64	Unknown	0	Unknown	Unknown	Unknown	See Figure 8	
Irrigation	SCW10073008	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10067952	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10089633	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10111621	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10132187	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10076108	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10070835	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Residential	SCW10089817	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10085043	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10078323	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10069439	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10098865	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10113165	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10106530	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Residential	SCW10103407	Redacted		Inactive	Unknown	Unknown	See Figure 8	
Irrigation	SCW10096362	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Residential	SCW08095132	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10116080	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Residential	SCW10135216	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10133232	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10110028	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10115943	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10137226	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Residential	SCW10084987	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10123642	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Residential	SCW10117545	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10089722	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10089723	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10070058	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10106440	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10076109	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10095050	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10131579	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10105445	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10114732	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Residential	SCW10090487	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10093723	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10080072	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10069182	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	
Irrigation	SCW10076307	Redacted		Active/Operating	Unknown	Unknown	See Figure 8	

Ir-	Table 8: Fol	rmer Charleston Na	ivai Complex, So	uth Carolina			
						Groundwater	
						protection	General
					Underlying	classification if	
		Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Irrigation	SCW10099220	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10081062	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10115405	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10088778	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10121015	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10125628	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10123435	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10072326	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10072327	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10072259	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10071662	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10121674	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10116559	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10099632	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10097913	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10090294	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10066652	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10131404	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10068157	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10129890	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10118955	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10111579	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10100851	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10090351	Redacted		Inactive	Unknown	Unknown	See Figure 8
Irrigation	SCW10084933	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10129863	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10119570	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10116081	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10077808	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08089493	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08128701	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10078748	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08074563	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential		Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10115138	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08114225	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10103980	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10100246	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10098938	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10095487	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10092921	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10092922	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10092923	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10092895	Redacted		Active/Operating	Unknown	Unknown	See Figure 8

	Table 8: For	rmer Charleston Na	avai Complex, Sc	outh Carolina			,
					Groundwater		
					1	protection	
					Underlying	classification if	General
—	34, 1131	Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Residential	SCW08091305	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10106441	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10105746	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10105747	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10069792	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10074431	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10116665	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10116667	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10087269	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10112683	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10134451	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10133646	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10134525	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10076833	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10068632	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10133037	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10126791	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10126384	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10125715	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10125716	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10125717	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10123447	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10122491	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10120378	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10120177	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10118032	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10117917	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10117151	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10116015	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10115797	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10111186	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10111139	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10110284	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10109605	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10100416	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10095557	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10091706	Redacted		Inactive	Unknown	Unknown	See Figure 8
Irrigation	SCW10091006	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10091010	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10090825	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10090648	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10082637	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10082078	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10081033	Redacted		Active/Operating	Unknown	Unknown	See Figure 8

I 	Table 8: For	mer Charleston Na	avai Complex, So	outh Carolina	•		
						Groundwater protection	
					Underlying	classification if	General
		Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Irrigation	SCW10079933	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10067149	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10070208	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10067177	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10127063	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10125391	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10120565	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10120428	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10119213	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10108093	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10100328	Redacted		Inactive	Unknown	Unknown	See Figure 8
Irrigation	SCW10096812	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10096813	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10124327	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10116875	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10105580	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10105370	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10098334	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10096383	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10082179	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10134541	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10130269	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08136080	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08136081	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08138315	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08136505	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10113353	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08072589	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10075011	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08128196	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10071737	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08128859	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08129031	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10113852	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10113416	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10107311	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08096110	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08096040	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10096039	Redacted		Inactive	Unknown	Unknown	See Figure 8
Irrigation	SCW08095970	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10095594	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10095440	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08121405	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08116912	Redacted		Active/Operating	Unknown	Unknown	See Figure 8

	Table 0.1 Of	mer Charleston Na	vai Complex, Sc	outh Carolina			
						Groundwater	
						protection	
					Underlying	classification if	General
		Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Residential	SCW10114472	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10111603	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10105486	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10105363	Redacted		Inactive	Unknown	Unknown	See Figure 8
Irrigation	SCW10103197	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08111276	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08131623	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10067999	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08090321	Redacted		Inactive	Unknown	Unknown	See Figure 8
Residential	SCW08084520	Redacted		Inactive	Unknown	Unknown	See Figure 8
Irrigation	SCW08083928	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10098659	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08098961	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10096704	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08095417	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08093440	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10083954	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08079170	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential		Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08125309	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10124641	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08122185	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10107130	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10099360	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW10098859	Redacted		Inactive	Unknown	Unknown	See Figure 8
Irrigation	SCW08095098	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10089070	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08103437	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW08130202	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10128416	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10136356	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10134805	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Irrigation	SCW08079921	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Residential	SCW10132339	Redacted		Active/Operating	Unknown	Unknown	See Figure 8
Private/ public drinking water	G08359	Redacted	Unknown	D	Unknown	Unknown	See Figure 8
Private/ public drinking water	G08395	Redacted	Unknown	D	Unknown	Unknown	See Figure 8
Private/ public drinking water	G10102	Redacted	Unknown	_	Unknown	Unknown	See Figure 8
Private/ public drinking water	G10280	Redacted	Unknown	D	Unknown	Unknown	See Figure 8
Private/ public drinking water	G08402	Redacted	Unknown		Unknown	Unknown	See Figure 8
Private/ public drinking water	G08460	Redacted	Unknown	D	Unknown	Unknown	See Figure 8
Private/ public drinking water	G08461	Redacted	Unknown	M	Unknown	Unknown	See Figure 8
Private/ public drinking water	G08463	Redacted	Unknown	M	Unknown	Unknown	See Figure 8
Private/ public drinking water	G08480	Redacted	Unknown	D	Unknown	Unknown	See Figure 8
ato, pasiis airiitiing water	03-02289SCW08048621	Redacted		Unknown	Unknown	Unknown	See Figure 8

	Table 8: For	mer Charleston Na	avai Complex, So	uth Carolina			· · · · · · · · · · · · · · · · · · ·
						Groundwater protection	
					Underlying	classification if	General
		Well Owner/	Depth/ Screen	Active use or	Aguifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Domestic	03-08129SCW08054074	Redacted	308	Unknown	Unknown	Unknown	See Figure 8
Domestic	03-05554SCW08051805	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	01-11706SCW08029567	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-08587SCW08011919	Redacted	340	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-08588SCW08011920	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-06395SCW08009827	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-05829SCW10023871	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-05832SCW10023874	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-06424SCW10024450	Redacted	45	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-06238SCW10024275	Redacted	35	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-04365SCW10022424	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-04368SCW10022427	Redacted	32	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-05182SCW10023224	Redacted	54	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-05204SCW10023246	Redacted	18	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-04872SCW10022923	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-07639SCW10025636	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-08606SCW10026570	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-08329SCW10026299	Redacted	340	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-08349SCW10026318	Redacted	37	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-06980SCW10024993	Redacted	20	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-06972SCW10024985	Redacted	40	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-06973SCW10024986	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-06992SCW10025005	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-07579SCW10025577	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-01539SCW10019781	Redacted	50	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-01310SCW10019553	Redacted	50	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-01192SCW10019438	Redacted	50	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-01311SCW10019554	Redacted	50	Unknown	Unknown	Unknown	See Figure 8
Domestic	01-00019SCW10018301	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-14806SCW10017953	Redacted	40	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-14850SCW10017997	Redacted	20	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-03404SCW10021573	Redacted	140	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-03857SCW10022004	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-02097SCW10020335	Redacted	40	Unknown	Unknown	Unknown	See Figure 8
Domestic	01-02974SCW10021159	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	02-03441SCW10035404	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	02-02091SCW10034098	Redacted	301	Unknown	Unknown	Unknown	See Figure 8
Irrigation	02-02836SCW10034813	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	02-02588SCW10034572	Redacted	301	Unknown	Unknown	Unknown	See Figure 8
Irrigation	02-06558SCW10038464	Redacted	47	Unknown	Unknown	Unknown	See Figure 8
Irrigation	02-12663SCW10044380	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-11328SCW10029200	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-12703SCW10030536	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-11110SCW10028992	Redacted		Unknown	Unknown	Unknown	See Figure 8

	Table 8: Fo	rmer Charleston Na	vai Complex, So	outh Carolina			
						Groundwater	
						protection	
					Underlying	classification if	General
		Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Irrigation	01-09050SCW10026997	Redacted	40	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-10630SCW10028524	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-10276SCW10028176	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	01-13567SCW10031383	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-01984SCW10005565	Redacted	15	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-02400SCW10005902	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-01524SCW10005147	Redacted	70	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-03005SCW10006474	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-00059SCW10003830	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-01266SCW10004913	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-01112SCW10004764	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-01177SCW10004827	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-10221SCW10013518	Redacted	38	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-08589SCW10011921	Redacted	17	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-12706SCW10015974	Redacted	19	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-13578SCW10016818	Redacted	318	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-08134SCW10011475	Redacted	32	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-08066SCW10011407	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-08121SCW10011462	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-03126SCW10006591	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	00-07981SCW10011327	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-06431SCW10009863	Redacted	340	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-06730SCW10010162	Redacted	45	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-06944SCW10010371	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-06720SCW10010152	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	00-06722SCW10010154	Redacted	60	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-09190SCW10065023	Redacted		Unknown	Unknown	Unknown	See Figure 8
Domestic	04-09109SCW10064942	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-03681SCW10069439	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-06156SCW10052329	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-04292SCW10050582	Redacted	38	Unknown	Unknown	Unknown	See Figure 8
Domestic	03-04426SCW10050714	Redacted	310	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-04142SCW10050437	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-05277SCW10051539	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-05303SCW10051564	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-06742SCW10052787	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-04812SCW10051087	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-06738SCW10052783	Redacted	27	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-09058SCW10054960	Redacted	65	Unknown	Unknown	Unknown	See Figure 8
Domestic	03-07296SCW10053279	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
Domestic	03-06882SCW10052885	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-06810SCW10052835	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-07966SCW10053911	Redacted	360	Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-07858SCW10053803	Redacted	25	Unknown	Unknown	Unknown	See Figure 8

I 	Table 8: For	mer Charleston Na	avai Complex, Sc	uth Carolina			
						Groundwater protection	
					Underlying	classification if	General
		Well Owner/	Danth/ Carean	Active use or	, ,	known and	Groundwater
Well Type	Wall Name and Identification		Depth/ Screen Intervals	inactive	Aquifer		
Well Type	Well Name and Identification	Agency			Information	applicable	Flow Direction
Irrigation	03-01405SCW10047810	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	02-12931SCW10044641	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-03261SCW10049574	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-03262SCW10049575	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-03137SCW10049455	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-03400SCW10049711	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	03-02784SCW10049107	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-04735SCW10060660	Redacted	20	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-05361SCW10061276	Redacted	28	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-05114SCW10061035	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-03712SCW10059650	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-03819SCW10059756	Redacted	20	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-06698SCW10062596	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-00654SCW10056647	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Domestic	04-01205SCW10057192	Redacted	63	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-00209SCW10056209	Redacted	28	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-02924SCW10058871	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-02607SCW10058557	Redacted	15	Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-03462SCW10059400	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-01874SCW10057843	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	04-01471SCW10057445	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10082637	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10085043	Redacted	360	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10084933	Redacted	80	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW10084987	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-01331SCW10067149	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-05982SCW10071662	Redacted	40	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-04043SCW10069792	Redacted	47	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-04316SCW10070058	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-02380SCW10068157	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-06597SCW10072259	Redacted	38	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-06668SCW10072326	Redacted	39	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-06669SCW10072327	Redacted	38	Unknown	Unknown	Unknown	See Figure 8
Domestic	05-08829SCW10074431	Redacted	67	Unknown	Unknown	Unknown	See Figure 8
Domestic	05-08961SCW08074563	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-02863SCW10068632	Redacted	23	Unknown	Unknown	Unknown	See Figure 8
Domestic	05-02950SCW38068717	Redacted	160	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-05127SCW10070835	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-07374SCW10073008	Redacted	46	Unknown	Unknown	Unknown	See Figure 8
Irrigation	05-03424SCW10069182	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10087269	Redacted	335	Unknown	Unknown	Unknown	See Figure 8
Irrigation	06-00545SCW10075812	Redacted	55	Unknown	Unknown	Unknown	See Figure 8
Irrigation	06-02582SCW10077808	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10079933	Redacted	0	Unknown	Unknown	Unknown	See Figure 8

Table 8: Former Charleston Naval Complex, South Carolina							1
						Groundwater	
						protection	
					Underlying	classification if	General
		Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
Irrigation	06-00854SCW10076108	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	06-00855SCW10076109	Redacted	35	Unknown	Unknown	Unknown	See Figure 8
Irrigation	06-01061SCW10076307	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
Irrigation	06-03108SCW10078323	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10080072	Redacted	45	Unknown	Unknown	Unknown	See Figure 8
Domestic	06-03540SCW10078748	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Irrigation	06-01602SCW10076833	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW10089070	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10088778	Redacted	28	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10081062	Redacted	24	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10081033	Redacted	20	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10082078	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10082179	Redacted	28	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10090294	Redacted	45	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10089722	Redacted	20	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10089723	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10090648	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW10090487	Redacted		Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW10089817	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10091006	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10091010	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10090821	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10090825	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10089633	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW10092895	Redacted	320	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10098334	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10098651	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10098865	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10097913	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW10098938	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW08095098	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10095050	Redacted	340	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW08093440	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10093723	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW08095132	Redacted	210	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10096362	Redacted	33	Unknown	Unknown	Unknown	See Figure 8
Domestic	CURSCW10095487	Redacted		Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10095557	Redacted	0	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10096383	Redacted	35	Unknown	Unknown	Unknown	See Figure 8
Existing	99-02305LEG	Redacted	160	Unknown	Unknown	Unknown	See Figure 8
	99-01648LEG	Redacted	180	Unknown	Unknown	Unknown	See Figure 8
	99-01614LEG	Redacted	300	Unknown	Unknown	Unknown	See Figure 8
	92-03034LEG	Redacted		Unknown	Unknown	Unknown	See Figure 8
	92-03226LEG	Redacted	320	Unknown	Unknown	Unknown	See Figure 8

Table 8: Former Charleston Naval Complex, South Carolina						
					•	
				, , ,		General
	Well Owner/	Depth/ Screen	Active use or	Aquifer		Groundwater
Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
92-03097LEG	Redacted	50	Unknown	Unknown	Unknown	See Figure 8
92-02509LEG				Unknown	Unknown	See Figure 8
92-02763LEG	Redacted	150	Unknown	Unknown	Unknown	See Figure 8
92-04028LEG	Redacted			Unknown	Unknown	See Figure 8
92-03595LEG	Redacted	205	Unknown	Unknown	Unknown	See Figure 8
00-13496SCW10016737	Redacted			Unknown	Unknown	See Figure 8
00-12145SCW10015426	Redacted	292	Unknown	Unknown	Unknown	See Figure 8
				Unknown	Unknown	See Figure 8
						See Figure 8
	Redacted	0	Unknown	Unknown		See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
		79	Unknown			See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
						See Figure 8
	Well Name and Identification 92-03097LEG 92-02509LEG 92-02763LEG 92-04028LEG 92-03595LEG	Well Name and Identification Well Owner/ Agency 92-03097LEG Redacted 92-02599LEG Redacted 92-02763LEG Redacted 92-03595LEG Redacted 00-13496SCW10016737 Redacted 00-12145SCW10015426 Redacted 00-13496SCW10007030 Redacted 00-03576SCW10007030 Redacted 00-04571SCW10008019 Redacted 92-01524LEG Redacted 92-01524LEG Redacted 92-02222LEG Redacted 92-01968LEG Redacted 92-01968LEG Redacted 92-01968LEG Redacted 92-01904LEG Redacted 92-01904LEG Redacted 94-00951LEG Redacted 94-00951LEG Redacted 94-00952LEG Redacted 94-01069LEG Redacted 94-01395LEG Redacted 94-01395LEG Redacted 94-01395LEG Redacted 94-01395LEG Redacted 94-01395LEG Red	Well Name and Identification Well Owner/ Agency Depth/ Screen Intervals 92-03097LEG Redacted 50 92-02763LEG Redacted 50 92-04028LEG Redacted 150 92-04028LEG Redacted 205 92-04928LEG Redacted 205 00-13496SCW10016737 Redacted 40 00-12145SCW10015426 Redacted 292 00-11634SCW10014916 Redacted 35 00-03576SCW10007030 Redacted 45 00-04571SCW10008019 Redacted 55 92-01524LEG Redacted 580 92-01222LEG Redacted 30 92-02222LEG Redacted 30 92-01968LEG Redacted 30 92-01968LEG Redacted 30 92-01968LEG Redacted 30 92-01904LEG Redacted 30 92-01904LEG Redacted 30 94-00951LEG Redacted 34 94-00951LEG Redacted	Well Name and Identification Well Owner/ Agency Depth/ Screen Intervals Active use or inactive 92-03097LEG Redacted 50 Unknown 92-02763LEG Redacted 50 Unknown 92-04028LEG Redacted 35 Unknown 92-04028LEG Redacted 35 Unknown 92-03595LEG Redacted 205 Unknown 00-13496SCW10016737 Redacted 40 Unknown 00-13495CW10015426 Redacted 292 Unknown 00-13345CW10016916 Redacted 35 Unknown 00-03876SCW100007030 Redacted 45 Unknown 00-04571SCW10008019 Redacted 55 Unknown 92-01524LEG Redacted 55 Unknown 92-02222LEG Redacted 30 Unknown 92-0252LEG Redacted 30 Unknown 92-01524LEG Redacted 30 Unknown 92-01948LEG Redacted 30 Unknown 92-01958LEG Redacted 30 Unknown 92-01944LEG Redacted 30 Unknown 92-04440LEG Redacted 30 Unknown </td <td>Well Name and Identification Well Owner/ Agency Depth/ Screen Intervals Active use or inactive Underlying Aquifer 92-03097LEG Redacted 50 Unknown Unknown 92-02599LEG Redacted 50 Unknown Unknown 92-02599LEG Redacted 50 Unknown Unknown 92-03985LEG Redacted 35 Unknown Unknown 00-13496SCW10016737 Redacted 205 Unknown Unknown 00-12145SCW10015426 Redacted 292 Unknown Unknown 00-11634SCW10014916 Redacted 292 Unknown Unknown 00-0457SSCW10007030 Redacted 35 Unknown Unknown 00-0457SSCW10008019 Redacted 45 Unknown Unknown 09-07688SCW10011091 Redacted 55 Unknown Unknown 09-07252LEG Redacted 30 Unknown Unknown 09-02052LEG Redacted 30 Unknown Unknown 09-021968LEG Redacted 30 Unknown Unknown 09-04189LEG Redacted 30 Unknown Unknown <!--</td--><td>Well Name and Identification Well Owner/ Agency Depth/ Screen Intervals Active use or Inactive Underlying Aquifer Information Groundwater protection of applicable 92-03097LEG Redacted 50 Unknown Unknown Unknown Unknown 92-02763LEG Redacted 50 Unknown Unknown Unknown Unknown 92-04028LEG Redacted 150 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 35 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 250 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 250 Unknown Unknown Unknown Unknown 92-0359SLEG Redacted 205 Unknown Unknown Unknown Unknown 90-1359CM10016373 Redacted 290 Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown<!--</td--></td></td>	Well Name and Identification Well Owner/ Agency Depth/ Screen Intervals Active use or inactive Underlying Aquifer 92-03097LEG Redacted 50 Unknown Unknown 92-02599LEG Redacted 50 Unknown Unknown 92-02599LEG Redacted 50 Unknown Unknown 92-03985LEG Redacted 35 Unknown Unknown 00-13496SCW10016737 Redacted 205 Unknown Unknown 00-12145SCW10015426 Redacted 292 Unknown Unknown 00-11634SCW10014916 Redacted 292 Unknown Unknown 00-0457SSCW10007030 Redacted 35 Unknown Unknown 00-0457SSCW10008019 Redacted 45 Unknown Unknown 09-07688SCW10011091 Redacted 55 Unknown Unknown 09-07252LEG Redacted 30 Unknown Unknown 09-02052LEG Redacted 30 Unknown Unknown 09-021968LEG Redacted 30 Unknown Unknown 09-04189LEG Redacted 30 Unknown Unknown </td <td>Well Name and Identification Well Owner/ Agency Depth/ Screen Intervals Active use or Inactive Underlying Aquifer Information Groundwater protection of applicable 92-03097LEG Redacted 50 Unknown Unknown Unknown Unknown 92-02763LEG Redacted 50 Unknown Unknown Unknown Unknown 92-04028LEG Redacted 150 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 35 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 250 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 250 Unknown Unknown Unknown Unknown 92-0359SLEG Redacted 205 Unknown Unknown Unknown Unknown 90-1359CM10016373 Redacted 290 Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown<!--</td--></td>	Well Name and Identification Well Owner/ Agency Depth/ Screen Intervals Active use or Inactive Underlying Aquifer Information Groundwater protection of applicable 92-03097LEG Redacted 50 Unknown Unknown Unknown Unknown 92-02763LEG Redacted 50 Unknown Unknown Unknown Unknown 92-04028LEG Redacted 150 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 35 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 250 Unknown Unknown Unknown Unknown 92-0399LEG Redacted 250 Unknown Unknown Unknown Unknown 92-0359SLEG Redacted 205 Unknown Unknown Unknown Unknown 90-1359CM10016373 Redacted 290 Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown </td

						Groundwater	
						protection	
					Underlying	classification if	General
		Wall Owner/	Danth/ Careen	Antivo una an	, ,		
347 - U. T	Wall Name on 11 lands at an	Well Owner/	Depth/ Screen	Active use or	Aquifer	known and	Groundwater
Well Type	Well Name and Identification	Agency	Intervals	inactive	Information	applicable	Flow Direction
	90-02632LEG	Redacted		Unknown	Unknown	Unknown	See Figure 8
	90-00829LEG	Redacted	55	Unknown	Unknown	Unknown	See Figure 8
	90-00831LEG	Redacted	55	Unknown	Unknown	Unknown	See Figure 8
	90-00250LEG	Redacted	35	Unknown	Unknown	Unknown	See Figure 8
	90-01338LEG	Redacted	65	Unknown	Unknown	Unknown	See Figure 8
	90-01027LEG	Redacted	35	Unknown	Unknown	Unknown	See Figure 8
	90-00949LEG	Redacted	65	Unknown	Unknown	Unknown	See Figure 8
	90-01273LEG	Redacted	65	Unknown	Unknown	Unknown	See Figure 8
	90-01274LEG	Redacted	60	Unknown	Unknown	Unknown	See Figure 8
	90-01128LEG	Redacted	30	Unknown	Unknown	Unknown	See Figure 8
	91-00859LEG	Redacted	180	Unknown	Unknown	Unknown	See Figure 8
	91-00693LEG	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
	91-00088LEG	Redacted	40	Unknown	Unknown	Unknown	See Figure 8
	91-01473LEG	Redacted	65	Unknown	Unknown	Unknown	See Figure 8
	90-04108LEG	Redacted	340	Unknown	Unknown	Unknown	See Figure 8
	90-03419LEG	Redacted	380	Unknown	Unknown	Unknown	See Figure 8
	90-03708LEG	Redacted	60	Unknown	Unknown	Unknown	See Figure 8
	90-04559LEG	Redacted	45	Unknown	Unknown	Unknown	See Figure 8
	91-02147LEG	Redacted	60	Unknown	Unknown	Unknown	See Figure 8
	91-02433LEG	Redacted	22	Unknown	Unknown	Unknown	See Figure 8
	91-01756LEG	Redacted	55	Unknown	Unknown	Unknown	See Figure 8
	91-03227LEG	Redacted	25	Unknown	Unknown	Unknown	See Figure 8
	91-03199LEG	Redacted		Unknown	Unknown	Unknown	See Figure 8
	91-02588LEG	Redacted	37	Unknown	Unknown	Unknown	See Figure 8
	98-00952LEG	Redacted		Unknown	Unknown	Unknown	See Figure 8
	98-03962LEG	Redacted	385	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10071737	Redacted	45	Unknown	Unknown	Unknown	See Figure 8
Irrigation	CURSCW10099220	Redacted	0	Unknown	Unknown	Unknown	See Figure 8

Notes:

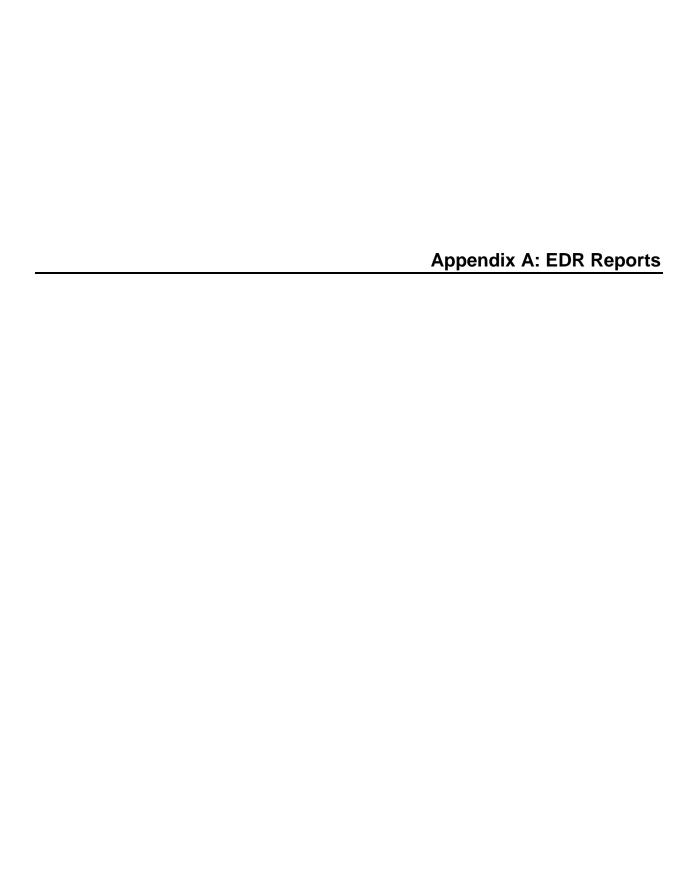
In the groundwater well data obtained from some states, private drinking water wells are identified by the name of the owner of the private property. To protect the privacy of these persons, their names (used as well labels or names) have been redacted in the text and/or on the figures of this report.

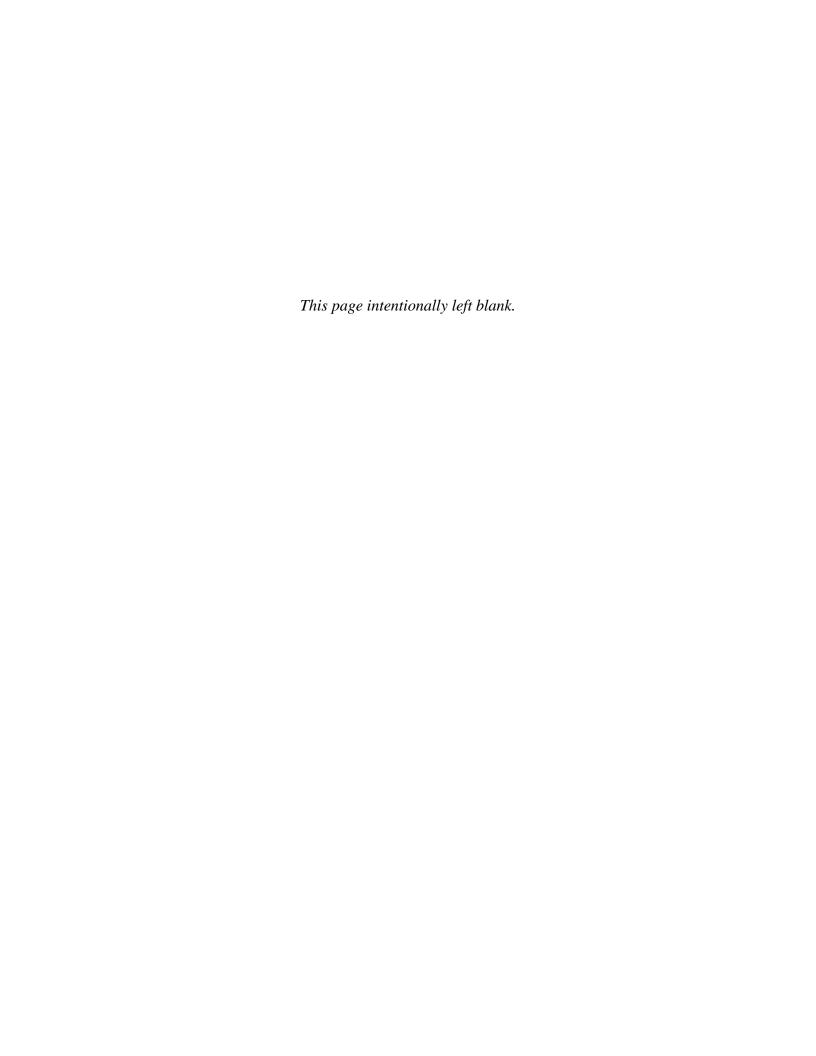
Wells identified with yellow highlights are located approximately one mile from a potential PFAS Site boundary, shown on Figure 8 and Table 1-2.

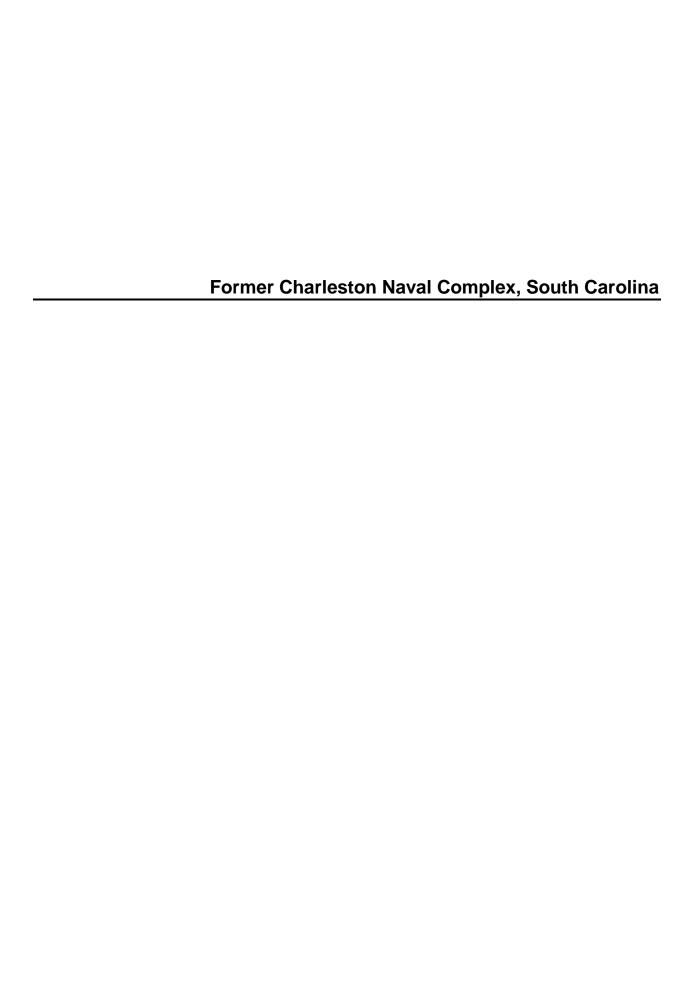
Sources:

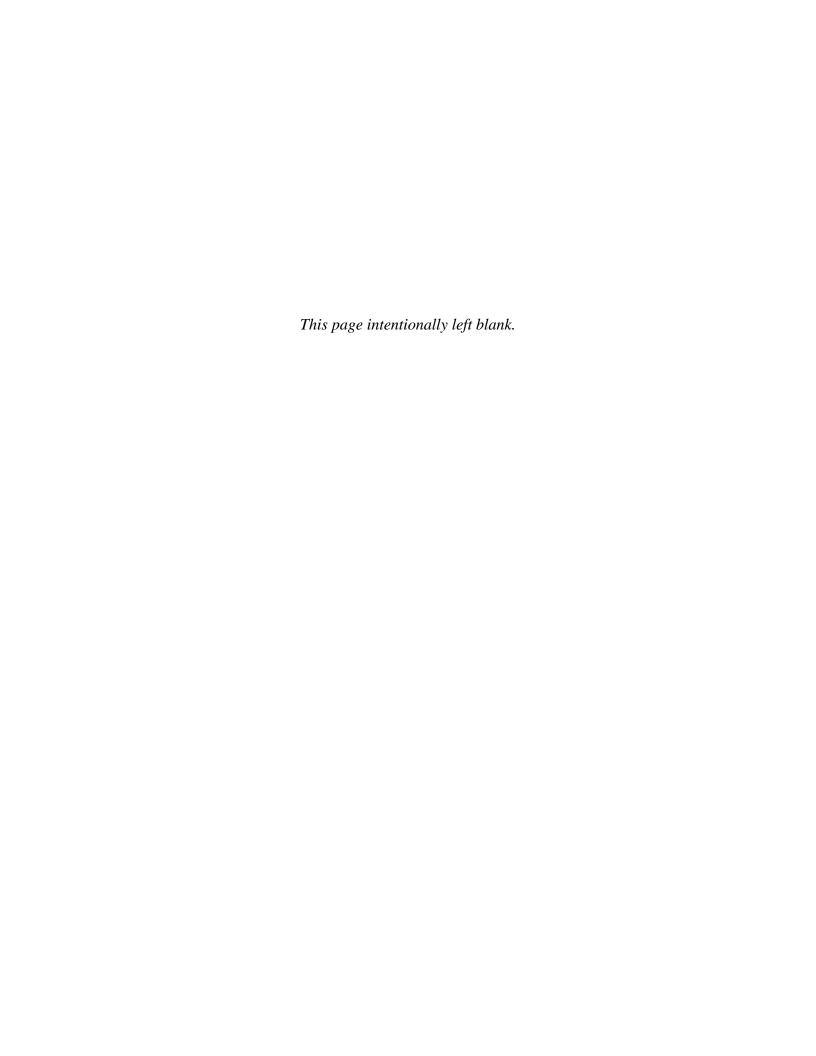
Environmental Data Resources Inc. (EDR)

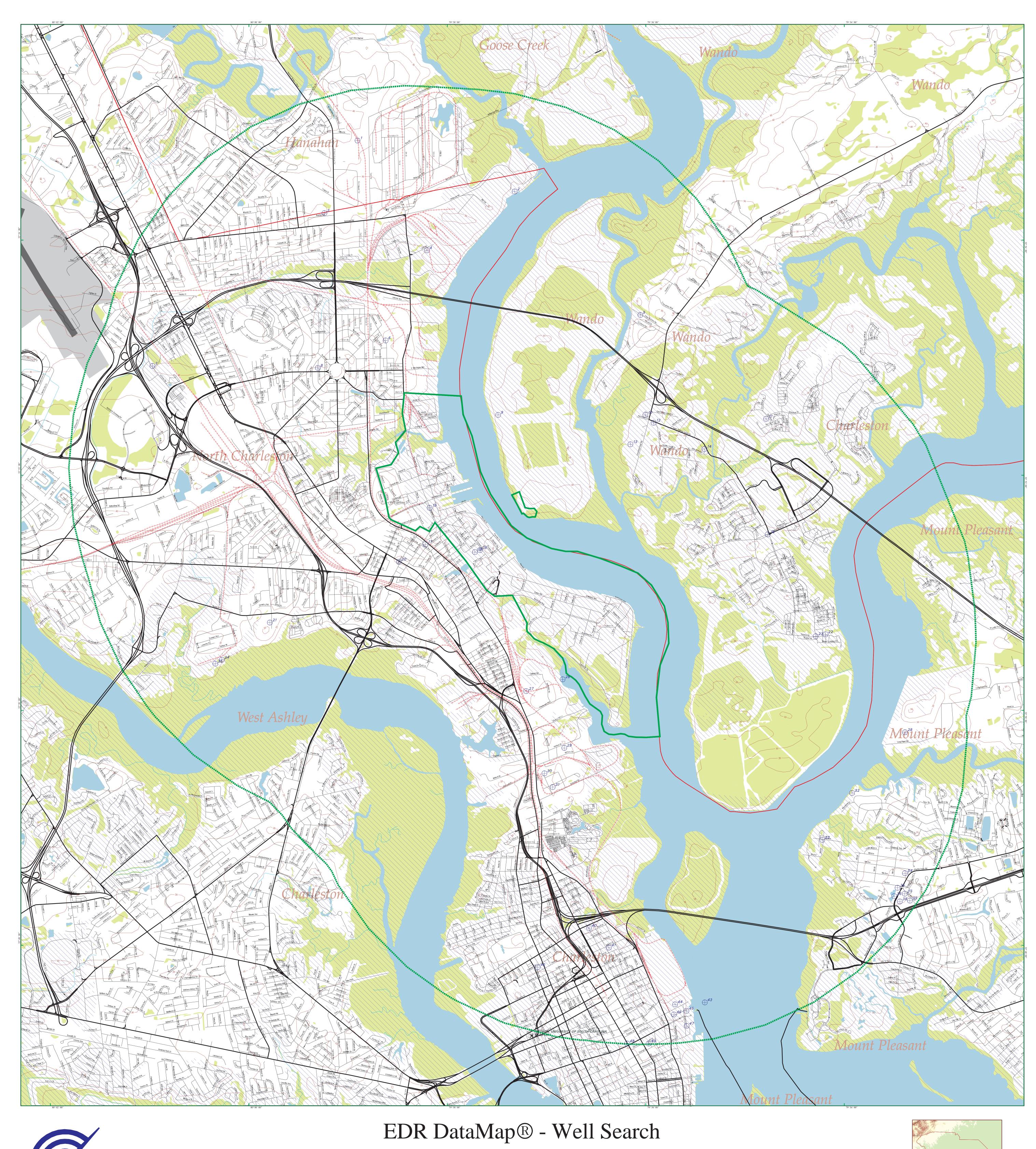
South Carolina Department of Health and Environmental Control









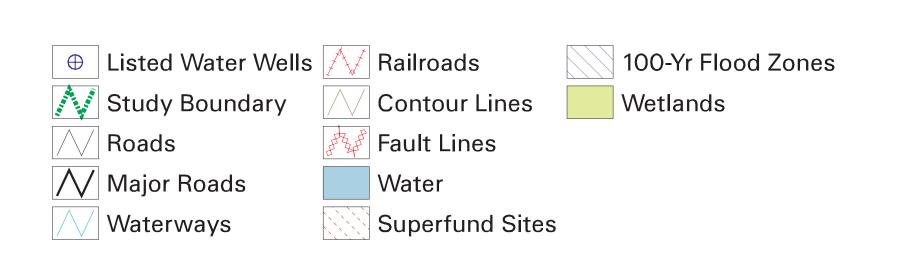


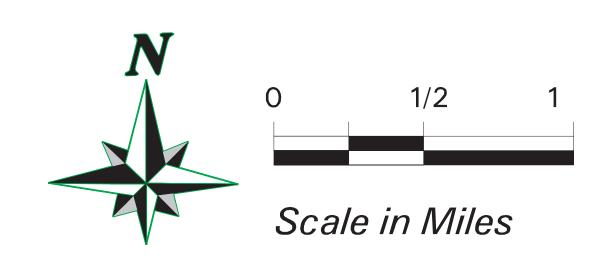


Charleston NS & Charleston NSY, SC



Charleston, SC





Charleston NS & Charleston NSY, SC

Charleston, SC 29405

Inquiry Number: 4663175.5w

July 07, 2016

EDR DataMap™ Well Search Report



Thank you for your business. Please contact EDR at 1-800-352-0050 with any questions or comments.

Disclaimer - Copyright and Trademark Notice

This Report contains certain information obtained from a variety of public and other sources reasonably available to Environmental Data Resources, Inc. It cannot be concluded from this Report that coverage information for the target and surrounding properties does not exist from other sources. NO WARRANTY EXPRESSED OR IMPLIED, IS MADE WHATSOEVER IN CONNECTION WITH THIS REPORT. ENVIRONMENTAL DATA RESOURCES, INC. SPECIFICALLY DISCLAIMS THE MAKING OF ANY SUCH WARRANTIES, INCLUDING WITHOUT LIMITATION, MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE OR PURPOSE. ALL RISK IS ASSUMED BY THE USER. IN NO EVENT SHALL ENVIRONMENTAL DATA RESOURCES, INC. BE LIABLE TO ANYONE, WHETHER ARISING OUT OF ERRORS OR OMISSIONS, NEGLIGENCE, ACCIDENT OR ANY OTHER CAUSE, FOR ANY LOSS OF DAMAGE, INCLUDING, WITHOUT LIMITATION, SPECIAL, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES. ANY LIABILITY ON THE PART OF ENVIRONMENTAL DATA RESOURCES, INC. IS STRICTLY LIMITED TO A REFUND OF THE AMOUNT PAID FOR THIS REPORT. Purchaser accepts this Report "AS IS". Any analyses, estimates, ratings, environmental risk levels or risk codes provided in this Report are provided for illustrative purposes only, and are not intended to provide, nor should they be interpreted as providing any facts regarding, or prediction or forecast of, any environmental risk for any property. Only a Phase I Environmental Site Assessment performed by an environmental professional can provide information regarding the environmental risk for any property. Additionally, the information provided in this Report is not to be construed as legal advice.

Copyright 2016 by Environmental Data Resources, Inc. All rights reserved. Reproduction in any media or format, in whole or in part, of any report or map of Environmental Data Resources, Inc., or its affiliates, is prohibited without prior written permission.

EDR and its logos (including Sanborn and Sanborn Map) are trademarks of Environmental Data Resources, Inc. or its affiliates. All other trademarks used herein are the property of their respective owners.

GEOCHECK VERSION 2.1 SUMMARY

FEDERAL DATABASE WELL INFORMATION

MAP ID	WELL ID
1	USGS40001052559
2	USGS40001052539
3	USGS40001052523
4	USGS40001052527
6	USGS40001052484
8	USGS40001052477
14	USGS40001052436
15	USGS40001052428
18	USGS40001052416
19	USGS40001052415
21	USGS40001052403
25	USGS40001052395
27	USGS40001052385
30	USGS40001052366
32	USGS40001052358
33	USGS40001052351
34	USGS40001052342
35	USGS40001052337
35	USGS40001052338
35	USGS40001052336
35	USGS40001052335
35	USGS40001052334
36	USGS40001052333
37	USGS40001052332
36	USGS40001052331
37	USGS40001052330
36	USGS40001052329
38	USGS40001052328
39	USGS40001052327
38	USGS40001052325
44	USGS40001052287
45	USGS40001052282
45	USGS40001052283
45	USGS40001052281
45	USGS40001052280
45	USGS40001052273
45	USGS40001052272
45	USGS40001052271
46	USGS40001052275
46	USGS40001052274
47	USGS40001052268

STATE WATER WELL INFORMATION

MAP ID	WELL <u>ID</u>
1	SCWC40000004928
2	SCWC40000004899
3	SCWC40000004690
4	SCWC40000004875
5	SCWC40000003397
6	SCWC40000004534
7	SCWC4000005173

GEOCHECK VERSION 2.1 SUMMARY

STATE WATER WELL INFORMATION

MAP	WELL
ID	<u>ID</u>
8	SCWC4000004829
9	SCWC4000003674
10	SCWC4000003667
11	SCWC4000003396
12	SCWC40000003387
13	SCWC4000003691
14	SCWC4000003638
15	SCWC40000004842
16	SCWC40000003395
18	SCWC40000004514
21	SCWC4000004603
22	SCWC4000003393
23	SCWC4000003394
24	SCWC40000004576
25	SCWC40000004575
26	SCWC40000004897
27	SCWC4000004900
28	SCWC4000004876
29	SCWC4000004886
29 30 31	SCWC40000004887 SCWC40000004592 SCWC40000004591 SCWC40000004582
32 33 34 35	SCWC40000004382 SCWC40000004688 SCWC40000004559
35	SCWC40000004612
35	SCWC40000004604
35	SCWC40000004562
35	SCWC40000004558
36	SCWC4000005089
37	SCWC40000004563
36	SCWC40000004561
37	SCWC40000004564
36	SCWC40000004560
38	SCWC40000004567
39	SCWC40000004565
38	SCWC40000004566
40	SCWC40000004521
41 43 44	SCWC40000004321 SCWC40000004520 SCWC40000004513 SCWC40000004522
45	SCWC4000005033
45	SCWC4000005027
45	SCWC4000005037
45	SCWC4000005035
45	SCWC4000005028
45	SCWC40000005032
45	SCWC4000005039
45	SCWC4000005029
45	SCWC4000005041
45	SCWC4000005042
45	SCWC4000005040
45	SCWC4000005030

GEOCHECK VERSION 2.1 SUMMARY

STATE WATER WELL INFORMATION

MAP ID	WELL <u>ID</u>
45	SCWC4000005031
45	SCWC4000005036
47	SCWC4000005038
47	SCWC4000005034
48	SCWC40000004519
49	SCWC40000004541

PUBLIC WATER SUPPLY SYSTEM INFORMATION

Map ID: 15

PWS ID: SC0860052

PWS Name: CLOVERLEAF MHP LOUIS J DIMUZIO

PO BOX 31318

CHARLESTON, SC 29417

PWS currently has or had major violation(s) or enforcement:

Map ID: 17

PWS ID: SC1070103

PWS Name: MCCLELLANVILLE LINCOLN

WILLIAM B SEARSON 2100 LEEDS AVENUE

CHARLESTON HGTS, SC 29405

PWS currently has or had major violation(s) or enforcement:

Map ID: 20

PWS ID: SC2570678
PWS Name: CAMP CHRISTIAN DAVID BROOKS

PO BOX 5246

NRTH CHARLESTON, SC 29406

PWS currently has or had major violation(s) or enforcement:

Map ID: 42

PWS ID: SC1070004
PWS Name: ESAU JENKINS

LEON L BURTON
51 NASSAU STREET

CHARLESTON, SC 29403

PWS currently has or had major violation(s) or enforcement:

USGS TOPOGRAPHIC MAP(S)

32079-G8 CHARLESTON, SC 32079-H8 NORTH CHARLESTON, SC 32080-G1 JOHNS ISLAND, SC 32080-H1 LADSON, SC

AREA RADON INFORMATION

GEOCHECK VERSION 2.1 SUMMARY

AREA RADON INFORMATION

Federal Area Radon Information for Zip Code:	29445
--	-------

Number of sites tested: 6

Number of sites tested: 6 Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor Living Area - 2nd Floor Basement	0.917 pCi/L Not Reported Not Reported	100% Not Reported Not Reported	0% Not Reported Not Reported	0% Not Reported Not Reported
Federal Area Radon Infor	mation for Zip Code: 2	29406		
Number of sites tested: 7				
Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor Living Area - 2nd Floor Basement	0.357 pCi/L Not Reported Not Reported	100% Not Reported Not Reported	0% Not Reported Not Reported	0% Not Reported Not Reported
Federal Area Radon Infor	mation for Zip Code: 2	29418		
Number of sites tested: 9				
Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor Living Area - 2nd Floor Basement	1.100 pCi/L Not Reported Not Reported	100% Not Reported Not Reported	0% Not Reported Not Reported	0% Not Reported Not Reported
Federal Area Radon Infor	mation for Zip Code: 2	29405		
Number of sites tested: 2				
Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor Living Area - 2nd Floor Basement	0.100 pCi/L Not Reported Not Reported	100% Not Reported Not Reported	0% Not Reported Not Reported	0% Not Reported Not Reported
Federal Area Radon Infor	mation for Zip Code: 2	29464		
Number of sites tested: 13	3			
Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
	-0.146 pCi/L	100%	0%	0%

GEOCHECK VERSION 2.1 SUMMARY

AREA RADON INFORMATION

Federal Area Radon Infor				
Number of sites tested: 1				
Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor Living Area - 2nd Floor Basement	0.407 pCi/L Not Reported 0.000 pCi/L	100% Not Reported 100%	0% Not Reported 0%	0% Not Reporte 0%
Federal Area Radon Infor	mation for Zip Code: 2	29401		
Number of sites tested: 3				
Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor Living Area - 2nd Floor Basement	-0.300 pCi/L Not Reported 0.000 pCi/L	100% Not Reported 100%	0% Not Reported 0%	0% Not Reporte 0%
: Zone 2 indoor a : Zone 3 indoor a	verage level > 4 pCi/L. verage level >= 2 pCi/L verage level < 2 pCi/L.			
: Zone 2 indoor a	verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for BERKELEY		% 4-20 pCi/L	% >20 pCi/L
: Zone 2 indoor a : Zone 3 indoor a Federal Area Radon Infor Number of sites tested: 1	verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for BERKELEY	COUNTY, SC	% 4-20 pCi/L 0% Not Reported 0%	% >20 pCi/L 0% Not Reporte 0%
: Zone 2 indoor a : Zone 3 indoor a Federal Area Radon Infor Number of sites tested: 1 Area Living Area - 1st Floor Living Area - 2nd Floor	verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for BERKELEY Average Activity 0.416 pCi/L Not Reported 0.000 pCi/L	COUNTY, SC % <4 pCi/L 100% Not Reported 100%	0% Not Reported	0% Not Reporte
: Zone 2 indoor a : Zone 3 indoor a : Zone 3 indoor a Federal Area Radon Infor Number of sites tested: 1 Area Living Area - 1st Floor Living Area - 2nd Floor Basement Federal EPA Radon Zone Note: Zone 1 indoor a : Zone 2 indoor a	verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for BERKELEY Average Activity 0.416 pCi/L Not Reported 0.000 pCi/L e for CHARLESTON Co	COUNTY, SC % <4 pCi/L 100% Not Reported 100% punty: 3	0% Not Reported	0% Not Reporte
: Zone 2 indoor a : Zone 3 indoor a : Zone 3 indoor a Federal Area Radon Infor Number of sites tested: 1 Area Living Area - 1st Floor Living Area - 2nd Floor Basement Federal EPA Radon Zone Note: Zone 1 indoor a : Zone 2 indoor a	verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for BERKELEY Average Activity 0.416 pCi/L Not Reported 0.000 pCi/L e for CHARLESTON Coverage level > 4 pCi/L verage level >= 2 pCi/L verage level < 2 pCi/L	COUNTY, SC % <4 pCi/L 100% Not Reported 100% punty: 3 and <= 4 pCi/L.	0% Not Reported	0% Not Reporte
: Zone 2 indoor a : Zone 3 indoor a : Zone 3 indoor a Federal Area Radon Infor Number of sites tested: 1 Area Living Area - 1st Floor Living Area - 2nd Floor Basement Federal EPA Radon Zone Note: Zone 1 indoor a : Zone 2 indoor a : Zone 3 indoor a	verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for BERKELEY Average Activity 0.416 pCi/L Not Reported 0.000 pCi/L e for CHARLESTON Coverage level > 4 pCi/L. verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for CHARLEST	COUNTY, SC % <4 pCi/L 100% Not Reported 100% punty: 3 and <= 4 pCi/L.	0% Not Reported	0% Not Reporte
: Zone 2 indoor a : Zone 3 indoor a : Zone 3 indoor a Federal Area Radon Infor Number of sites tested: 1 Area Living Area - 1st Floor Living Area - 2nd Floor Basement Federal EPA Radon Zone Note: Zone 1 indoor a : Zone 2 indoor a : Zone 3 indoor a	verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for BERKELEY Average Activity 0.416 pCi/L Not Reported 0.000 pCi/L e for CHARLESTON Coverage level > 4 pCi/L. verage level >= 2 pCi/L verage level < 2 pCi/L. rmation for CHARLEST	COUNTY, SC % <4 pCi/L 100% Not Reported 100% punty: 3 and <= 4 pCi/L.	0% Not Reported	0% Not Reporte

Water Well Information:

Map ID:

Org. Identifier: USGS-SC Site ID: USGS40001052559

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325450079585509

Monloc name: CHN- 639 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Not Reported Huc code: Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported 32.914063 Latitude: Longitude: -79.9817533 Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 35 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode:

Aquifername: Not Reported Formation type: Not Reported Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 380

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 2

Org. Identifier: USGS-SC Site ID: USGS40001052530

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325424079572009

Monloc name: CHN- 609 Monloc type: Well

Monloc desc: Data from SCDNR digital data base, USGS Rasa 2005

Huc code: Not Reported Drainagearea value: Not Reported Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported 32.9068408 Latitude: -79.9553638 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 10 Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet
Vertcollection method: Unknown

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Not Reported Formation type: Not Reported

US

Aquifer type: Not Reported

Construction date: 198607 Welldepth: 415

Welldepth units: Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 3

Org. Identifier: **USGS-SC** Site ID: USGS40001052523

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325413079591509

CHN- 294 Monloc name: Monloc type: Well

Data from SCDNR 2004 RASA 2004 database Monloc desc:

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.9037854 -79.9873093 Not Reported Longitude: Sourcemap scale: Horiz Acc measure units: seconds

Horiz Acc measure:

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 40 Vert measure units: 0.1 feet Vertacc measure val:

Vert accmeasure units:

Vertcollection method: Interpolated from topographic map

NGVD29 US Vert coord refsys: Countrycode:

Aquifername: Not Reported Formation type: Not Reported Not Reported Aquifer type:

Welldepth: Construction date: Not Reported 361

Wellholedepth: Not Reported Welldepth units: ft

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID:

Org. Identifier: **USGS-SC** Site ID: USGS40001052507

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325354079581309

CHN- 540 Monloc name: Monloc type: Well

Data from SCDNR 2004 RASA 2004 database Monloc desc:

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8985077 -79.9700867 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

NAD83 15 Horiz coord refsys: Vert measure val: Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

NGVD29 Vert coord refsys: US Countrycode:

Aquifername: Not Reported Formation type: Not Reported

Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 450

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 6

Org. Identifier: USGS-SC Site ID: USGS40001052484

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325308079583809

Monloc name: CHN- 49
Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8857302 -79.9770317 Not Reported Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 30 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Not Reported
Formation type: Not Reported
Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 440 Welldepth units: ft Wellholedepth: 515

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 8

Org. Identifier: USGS-SC Site ID: USGS40001052477

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325254079591909

Monloc name: CHN- 460 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8818414 -79.9884211 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 30 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Floridan aquifer system Floridan Aquifer System

Aquifer type: Confined single aquifer

Construction date: Not Reported Welldepth: 325

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 14

Org. Identifier: USGS-SC Site ID: USGS40001052436

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325213079552501

Monloc name: BRK- 641 Monloc type: Well

Monloc desc: SANTEE NAWQA FLORIDAN AQUIFER SUB-UNIT SURVEY 1998

Drainagearea value: Huc code: 03050201 Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Not Reported 32.8702083 Contrib drainagearea units: Not Reported Latitude: -79.9236306 24000 Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Global positioning system (GPS), uncorrected

Horiz coord refsys: NAD83 Vert measure val: 5
Vert measure units: feet Vertacc measure val: 2.5

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Floridan aquifer system
Formation type: Floridan Aquifer System
Aquifer type: Confined single aquifer

Construction date: 19860911 Welldepth: 300
Welldepth units: ft Wellholedepth: 300

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 15

Org. Identifier: USGS-SC Site ID: USGS40001052428

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325143079581109

Monloc name: CHN- 476 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8621196 -79.9695321 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 20 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Not Reported Formation type: Not Reported

Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 315

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 18

Org. Identifier: USGS-SC Site ID: USGS40001052416

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325121079574100

Monloc name: CHN- 2 Monloc type: Well

Monloc desc: FROM SCDNR WELL REPORT

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Drainagearea Units: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8560085 -79.9611986 24000 Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Interpolated from map

Horiz coord refsys: NAD83 Vert measure val: 12
Vert measure units: feet Vertacc measure val: 001

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Southeastern Coastal Plain aquifer system

Formation type: Middendorf Formation Aquifer type: Confined single aquifer

Construction date: 194303 Welldepth: 2016 Welldepth units: ft Wellholedepth: 2136

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 19

Org. Identifier: USGS-SC Site ID: USGS40001052415

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325120079574409

Monloc name: CHN- 121 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8557308 -79.962032 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 35 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Not Reported Formation type: Not Reported

Aquifer type: Not Reported

Construction date: Not Reported Welldepth:

Welldepth units: Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 21

Org. Identifier: **USGS-SC** Site ID: USGS40001052403

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325044079594809

Monloc name: CHN- 151 Monloc type: Well

Monloc desc: Data from SCDNR digital data base, USGS Rasa 2005

Drainagearea value: Not Reported Huc code: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8457311 -79.9964779 Not Reported Longitude: Sourcemap scale: Horiz Acc measure units: seconds

Horiz Acc measure:

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 25 Vert measure units: Vertacc measure val: feet 1

Vert accmeasure units: feet Vertcollection method: Unknown

NGVD29 US Vert coord refsys: Countrycode:

Not Reported Aquifername: Formation type: Not Reported Not Reported Aquifer type:

Construction date: Not Reported Welldepth: 400

Wellholedepth: Not Reported Welldepth units: ft

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 25

Org. Identifier: **USGS-SC** Site ID: USGS40001052395

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325023080002109

CHN- 107 Monloc name: Monloc type: Well

Data from SCDNR 2004 RASA 2004 database Monloc desc:

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8398979 -80.0056451 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

NAD83 8 Horiz coord refsys: Vert measure val: Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 US Countrycode:

Aquifername: Not Reported Formation type: Not Reported

Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 450

Welldepth units: Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 27

Org. Identifier: **USGS-SC** Site ID: USGS40001052385

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-325009079571309

CHN- 610 Monloc name: Monloc type: Well

Data from SCDNR 2004 RASA 2004 database Monloc desc:

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8360089 -79.9534211 Not Reported Longitude: Sourcemap scale: Horiz Acc measure units: seconds

Horiz Acc measure:

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 10 Vert measure units: 0.1 feet Vertacc measure val:

Vert accmeasure units:

Vertcollection method: Interpolated from topographic map

US NGVD29 Vert coord refsys: Countrycode:

Aquifername: Not Reported Formation type: Not Reported Not Reported Aguifer type:

Construction date: Not Reported Welldepth: 440

Wellholedepth: Not Reported Welldepth units: ft

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 30

Org. Identifier: **USGS-SC** Site ID: USGS40001052366

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324927079570209

Monloc name: CHN- 137 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Not Reported Huc code: Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8243425 -79.9503657 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

NAD83 15 Horiz coord refsys: Vert measure val: Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 US Countrycode:

Aquifername: Not Reported Formation type: Not Reported

Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 510 Welldepth units: ft Wellholedepth: 510

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 32

Org. Identifier: USGS-SC Site ID: USGS40001052358

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324917079535609

Monloc name: CHN- 115 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8215646 -79.8986971 Not Reported Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 10
Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Not Reported Formation type: Not Reported Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 350

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 33

Org. Identifier: USGS-SC Site ID: USGS40001052351

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324853079541409

Monloc name: CHN- 289 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8148981 -79.9036975 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 6
Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Floridan aquifer system Formation type: Floridan Aquifer System

Aquifer type: Confined single aquifer

Construction date: Not Reported Welldepth: 344

Welldepth units: Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 34

Org. Identifier: **USGS-SC** Site ID: USGS40001052342

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324836079532409

CHN- 292 Monloc name: Monloc type: Well

Data from SCDNR 2004 RASA 2004 database Monloc desc:

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8101759 -79.8898081 Not Reported Longitude: Sourcemap scale: Horiz Acc measure units: seconds

Horiz Acc measure:

Horiz Collection method: Unknown Horiz coord refsys: NAD83 Vert measure val:

Vert measure units: 0.1 feet Vertacc measure val:

Vert accmeasure units:

Vertcollection method: Interpolated from topographic map

US Vert coord refsys: NGVD29 Countrycode:

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Unconfined single aquifer Aquifer type:

Construction date: Not Reported Welldepth: 26

Wellholedepth: Not Reported Welldepth units: ft

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 35

Org. Identifier: **USGS-SC** Site ID: USGS40001052337

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324829079533000

CHN- 167 Monloc name: Monloc type: Well

FROM SCDNR WELL REPORT FORM Monloc desc:

Not Reported Huc code: Drainagearea value: Not Reported Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8082315 Longitude: -79.8914749 Sourcemap scale: 24000 Horiz Acc measure: 5 Horiz Acc measure units: seconds

Horiz Collection method: Interpolated from map

NAD83 24.00 Horiz coord refsys: Vert measure val: Vert measure units: feet Vertacc measure val: 001

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

NGVD29 Vert coord refsys: US Countrycode:

Aquifername: Not Reported Formation type: Not Reported 20

Aquifer type: Not Reported

Construction date: 19690701 Welldepth: 1986 Welldepth units: ft Wellholedepth: 1993

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 35

Org. Identifier: USGS-SC Site ID: USGS40001052338

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324829079533009

Monloc name: CHN- 87 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8082315 -79.8914749 Not Reported Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 24
Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 60

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 35

Org. Identifier: USGS-SC Site ID: USGS40001052336

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324829079532909

Monloc name: CHN- 152 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8082315 -79.8911971 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 24 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Not Reported Formation type: Not Reported

Aquifer type: Not Reported

Construction date: Not Reported Welldepth: 515

Welldepth units: Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 35

Org. Identifier: **USGS-SC** Site ID: USGS40001052335

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324829079532709

CHN- 90 Monloc name: Monloc type: Well

Data from SCDNR 2004 RASA 2004 database Monloc desc:

Not Reported Huc code: Not Reported Drainagearea value: Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8082315 -79.8906415 Not Reported Longitude: Sourcemap scale: Horiz Acc measure units: seconds

Horiz Acc measure:

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 22 Vert measure units: 0.1 feet Vertacc measure val:

Vert accmeasure units:

Vertcollection method: Interpolated from topographic map

US NGVD29 Vert coord refsys: Countrycode:

Surficial aquifer system Aquifername:

Formation type: Sand Deposits

Unconfined single aquifer Aguifer type:

Construction date: Not Reported Welldepth: 55 Wellholedepth: Welldepth units: ft 120

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 35

Org. Identifier: **USGS-SC** Site ID: USGS40001052334

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324828079532809

Monloc name: CHN- 86 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Not Reported Huc code: Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8079537 -79.8909193 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

NAD83 22 Horiz coord refsys: Vert measure val: Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 US Countrycode:

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth:

Welldepth units: Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 36

Org. Identifier: **USGS-SC** Site ID: USGS40001052333

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324827079533200

CHN- 875 Monloc name: Monloc type: Well Monloc desc: Not Reported

Drainagearea value: Not Reported Huc code: Not Reported Not Reported Contrib drainagearea: Drainagearea Units: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8075 -79.8922222 24000 Longitude: Sourcemap scale: seconds

Horiz Acc measure: Horiz Acc measure units:

Horiz Collection method: Global positioning system (GPS), uncorrected

Horiz coord refsys: NAD83 Vert measure val: 20 Vert measure units: feet Vertacc measure val: 5

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

NAVD88 Countrycode: US Vert coord refsys:

Southeastern Coastal Plain aquifer system Aquifername:

Formation type: Black Creek Formation Confined single aquifer Aguifer type:

Construction date: 20050815 Welldepth: 1355 Wellholedepth: Welldepth units: ft 1445.5

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 37

Org. Identifier: **USGS-SC** Site ID: USGS40001052332

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324826079532509

CHN- 91 Monloc name: Monloc type: Well

Data from SCDNR 2004 RASA 2004 database Monloc desc:

Not Reported Huc code: Not Reported Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8073982 -79.890086 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

NAD83 20 Horiz coord refsys: Vert measure val: Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 US Countrycode:

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 44
Welldepth units: ft Wellholedepth: 65

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 36

Org. Identifier: USGS-SC Site ID: USGS40001052331

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324825079533009

Monloc name: CHN- 89 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Huc code: Not Reported Drainagearea value: Not Reported Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8071204 -79.8914749 Not Reported Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 22 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 44
Welldepth units: ft Wellholedepth: 48

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 37

Org. Identifier: USGS-SC Site ID: USGS40001052330

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324825079532309

Monloc name: CHN- 92 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Not Reported Huc code: Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8071204 -79.8895304 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 20 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 44
Welldepth units: ft Wellholedepth: 65

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 36

Org. Identifier: USGS-SC Site ID: USGS40001052329

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324824079533109

Monloc name: CHN- 88
Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Huc code: Not Reported Drainagearea value: Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8068427 -79.8917527 Not Reported Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 22 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 45
Welldepth units: ft Wellholedepth: 50

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 38

Org. Identifier: USGS-SC Site ID: USGS40001052328

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324822079532809

Monloc name: CHN- 95 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Not Reported Huc code: Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8062871 -79.8909194 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 20 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 49
Welldepth units: ft Wellholedepth: 65

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 39

Org. Identifier: USGS-SC Site ID: USGS40001052327

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324822079532109

Monloc name: CHN- 93 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Huc code: Not Reported Drainagearea value: Not Reported Contrib drainagearea: Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.8062871 -79.8889748 Not Reported Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 20 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 50 Welldepth units: ft Wellholedepth: 65

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 38

Org. Identifier: USGS-SC Site ID: USGS40001052325

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324821079532609

Monloc name: CHN- 94 Monloc type: Well

Monloc desc: Data from SCDNR 2004 RASA 2004 database

Not Reported Not Reported Huc code: Drainagearea value: Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.8060093 -79.8903638 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 20 Vert measure units: feet Vertacc measure val: 0.1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 50 Welldepth units: ft Wellholedepth: 65

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 44

Org. Identifier: USGS-SC Site ID: USGS40001052287

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324729079472001

Monloc name: CHN- 14
Monloc type: Well

Monloc desc: Longitude 10 seconds different from site id

03050202 Huc code: Drainagearea value: Not Reported Not Reported Contrib drainagearea: Drainagearea Units: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.7915653 -79.9284212 24000 Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Interpolated from map

Horiz coord refsys: NAD83 Vert measure val: 7.5
Vert measure units: feet Vertacc measure val: .04

Vert accmeasure units: feet

Vertcollection method: Level or other surveying method

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Southeastern Coastal Plain aquifer system

Formation type: Middendorf Formation Aquifer type: Confined single aquifer

Construction date: 1911 Welldepth: 2007

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 1

Feet below Feet to
Date Surface Sealevel

1990-01-26 10.00

Map ID: 45

Org. Identifier: USGS-SC Site ID: USGS40001052282

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324726079553800

Monloc name: A3-T1
Monloc type: Well
Monloc desc: Not Reported

Huc code:Not ReportedDrainagearea value:Not ReportedDrainagearea Units:Not ReportedContrib drainagearea:Not ReportedContrib drainagearea units:Not ReportedLatitude:32.790775Longitude:-79.9272806Sourcemap scale:Not Reported

Horiz Acc measure: .01 Horiz Acc measure units: seconds

Horiz Collection method: Global positioning system (GPS), uncorrected

Horiz coord refsys: NAD83 Vert measure val: 10 Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NAVD88 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Not Reported Aquifer type: Not Reported

Construction date: Not Reported Welldepth: Not Reported Welldepth units: Not Reported Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 45

Org. Identifier: USGS-SC Site ID: USGS40001052283

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324726079553809

Monloc name: CHN- 770 Monloc type: Well

Monloc desc: Data from SCDNR digital data base, USGS Rasa 2005

Huc code: Not Reported Drainagearea value: Not Reported Contrib drainagearea: Not Reported Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.790732 -79.9270322 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: seconds Horiz Acc measure units:

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 6
Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet

Vertcollection method: Unknown

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: 199208 Welldepth: 12
Welldepth units: ft Wellholedepth: 12

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 45

Org. Identifier: USGS-SC Site ID: USGS40001052281

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324726079553509

Monloc name: CHN- 780 Monloc type: Well

Monloc desc: Data from SCDNR digital data base, USGS Rasa 2005

Huc code:Not ReportedDrainagearea value:Not ReportedDrainagearea Units:Not ReportedContrib drainagearea:Not ReportedContrib drainagearea units:Not ReportedLatitude:32.790732Longitude:-79.9261989Sourcemap scale:Not Reported

Horiz Acc measure: 1 Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 6
Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet
Vertcollection method: Unknown
Vert coord refsys: NGVD29

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: 199208 Welldepth: 27
Welldepth units: ft Wellholedepth: 27

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 45

Org. Identifier: USGS-SC Site ID: USGS40001052280

Formal name: USGS South Carolina Water Science Center Monloc Identifier: USGS-324726079553409

Monloc Identifier: USGS-324
Monloc name: CHN- 778
Monloc type: Well

Monloc desc: Data from SCDNR digital data base, USGS Rasa 2005

Huc code: 03050202 Drainagearea value: Not Reported Contrib drainagearea: Not Reported Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.790732 -79.9259211 24000 Longitude: Sourcemap scale: Horiz Acc measure: seconds Horiz Acc measure units:

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 7
Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet

Vertcollection method: Unknown

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: 199208 Welldepth: 20 Welldepth units: ft Wellholedepth: 20

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 45

Org. Identifier: USGS-SC Site ID: USGS40001052273

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324724079553701

Monloc name: CHN- 784 Monloc type: Well

Monloc desc: CHARLESTON AQUARIUM SITE

Huc code:03050201Drainagearea value:Not ReportedDrainagearea Units:Not ReportedContrib drainagearea:Not ReportedContrib drainagearea units:Not ReportedLatitude:32.7901764Longitude:-79.9267545Sourcemap scale:24000

Horiz Acc measure: 5 Horiz Acc measure units: seconds

Horiz Collection method: Interpolated from map

Horiz coord refsys: NAD83 Vert measure val: 6.01 Vert measure units: 6et Vertacc measure val: .01

Vert accmeasure units: feet

Vertcollection method: Level or other surveying method

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: 19931117 Welldepth: 13

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 45

Org. Identifier: USGS-SC Site ID: USGS40001052272

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324724079553700

Monloc name: CHN- 783 Monloc type: Well

Monloc desc: CHARLESTON AQUARIUM SITE

Huc code: 03050201 Drainagearea value: Not Reported Not Reported Not Reported Drainagearea Units: Contrib drainagearea: Contrib drainagearea units: Not Reported Latitude: 32.7901764 -79.9267545 24000 Longitude: Sourcemap scale: Horiz Acc measure: seconds Horiz Acc measure units:

Horiz Collection method: Interpolated from map

Horiz coord refsys: NAD83 Vert measure val: 6.07 Vert measure units: 6eet Vertacc measure val: .01

Vert accmeasure units: feet

Vertcollection method: Level or other surveying method

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system
Formation type: Sand Deposits
Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: 42

Welldepth units: ft Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 45

Org. Identifier: USGS-SC Site ID: USGS40001052271

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324724079553509

Monloc name: CHN- 779 Monloc type: Well

Monloc desc: Data from SCDNR digital data base, USGS Rasa 2005

Huc code:Not ReportedDrainagearea value:Not ReportedDrainagearea Units:Not ReportedContrib drainagearea:Not ReportedContrib drainagearea units:Not ReportedLatitude:32.7901764Longitude:-79.9261989Sourcemap scale:Not Reported

Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 7 Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet Vertcollection method: Unknown

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system

Sand Deposits Formation type:

Unconfined single aquifer Aquifer type:

Construction date: 199208 Welldepth: 18 Welldepth units: Wellholedepth: 18 ft

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Map ID: 46

Org. Identifier: **USGS-SC** Site ID: USGS40001052275

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324724079554300

Monloc name: USGS-1 Well Monloc type: Monloc desc: Not Reported Huc code:

Not Reported Drainagearea value: Not Reported Not Reported Not Reported Drainagearea Units: Contrib drainagearea: Contrib drainagearea units: Not Reported Latitude: 32.7901444 -79.9286361 24000 Longitude: Sourcemap scale: Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Global positioning system (GPS), uncorrected

NAD83 10 Horiz coord refsys: Vert measure val: Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

NAVD88 US Vert coord refsys: Countrycode:

Aquifername: Surficial aquifer system Formation type: Not Reported Unconfined single aquifer Aquifer type:

Construction date: Not Reported Welldepth: Not Reported Welldepth units: Not Reported Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 46

Org. Identifier: USGS40001052274 **USGS-SC** Site ID:

USGS South Carolina Water Science Center Formal name:

Monloc Identifier: USGS-324724079554200

USGA-A Monloc name: Monloc type: Well Monloc desc:

Not Reported Huc code: Not Reported

Drainagearea value: Not Reported Drainagearea Units: Not Reported Contrib drainagearea: Not Reported Contrib drainagearea units: Not Reported Latitude: 32.7901222 Longitude: -79.9285806 Sourcemap scale: 24000

Horiz Acc measure: .01 Horiz Acc measure units: seconds

Horiz Collection method: Global positioning system (GPS), uncorrected

Horiz coord refsys: NAD83 Vert measure val: 10 Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet

Vertcollection method: Interpolated from topographic map

Vert coord refsys: NAVD88 Countrycode: US

Aquifername: Surficial aquifer system

Formation type: Not Reported

Aquifer type: Unconfined single aquifer

Construction date: Not Reported Welldepth: Not Reported Welldepth units: Not Reported Wellholedepth: Not Reported

Wellholedepth units: Not Reported

Ground-water levels, Number of Measurements: 0

Map ID: 47

Org. Identifier: USGS-SC Site ID: USGS40001052268

Formal name: USGS South Carolina Water Science Center

Monloc Identifier: USGS-324718079553709

Monloc name: CHN- 781 Monloc type: Well

Monloc desc: Data from SCDNR digital data base, USGS Rasa 2005

Drainagearea value: Huc code: Not Reported Not Reported Contrib drainagearea: Not Reported Not Reported Drainagearea Units: Contrib drainagearea units: Not Reported Latitude: 32.7885098 -79.9267545 Longitude: Sourcemap scale: Not Reported Horiz Acc measure: Horiz Acc measure units: seconds

Horiz Collection method: Unknown

Horiz coord refsys: NAD83 Vert measure val: 6
Vert measure units: feet Vertacc measure val: 1

Vert accmeasure units: feet

Vertcollection method: Unknown

Vert coord refsys: NGVD29 Countrycode: US

Aquifername: Surficial aquifer system Formation type: Sand Deposits

Aquifer type: Unconfined single aquifer

Construction date: 199208 Welldepth: 17 Welldepth units: ft Wellholedepth: 17

Wellholedepth units: ft

Ground-water levels, Number of Measurements: 0

Water Well Information:

Filename:

Filename:

Site id:

Site id:

Map ID:	1			
Fid:	4927	Conum:	CHN-639	
Scgrid:	18CC-d1			
Lat:	325450			
Lon:	795855			
Utm e:	595199	Utm n:	3642009	
Topo:	North Charleston	Elev:	35	
Owner:	USAF Tank Farm	Owner well:	Not Reported	
Location:	Hanahan	Use :	IND .	
Depth d:	381	Depth c:	381	
Diam 1:	6	Diam 2:	3	
Oh cas:	0	Screen t:	305	
Screen b:	375	Drill yr:	1991	
Drill mo:	11	Yield:	50	
Yield yr:	1991	G logs:	E, G,	
D logs:	1	P test:	1	
Chem:	С	WI:	62	
WI yr:	1991	Driller:	Layne-Atlantic	

Map ID:	2		
Fid:	4898	Conum:	CHN-609
Scgrid:	18CC-c1		
Lat:	325424		
Lon:	795720		
Utm e:	597675	Utm n:	3641233
Topo:	North Charleston	Elev:	10
Owner:	Westvaco Paper Mill	Owner well:	Not Reported
Location:	Not Reported	Use :	IND
Depth d:	0	Depth c:	415
Diam 1:	6	Diam 2:	0
Oh cas:	105	Screen t:	0
Screen b:	0	Drill yr:	1986
Drill mo:	7	Yield:	180
Yield yr:	0	G logs:	Not Reported
D logs:	1	P test:	0
Chem:	Not Reported	WI:	41
WI yr:	0	Driller:	Ackerman

Coastal_Plain_wells.xls

Coastal_Plain_wells.xls SCWC40000004899

SCWC40000004928

 Map ID:
 3

 Fid:
 4689
 Conum:
 CHN-294

 Scgrid:
 18CC-e1

 Lat:
 325413

 Lon:
 795915

 Utm e:
 594690

 Utm e:
 594690
 Utm n:
 3640865

 Topo:
 North Charleston
 Elev:
 40

 Owner:
 Westvaco Paper Mill
 Owner well:
 Not Reported

Location: Athletic Club, N. Chas. REC Use: Depth d: 361 Depth c: 361 6 Diam 1: Diam 2: 0 Oh cas: 198 Screen t: 0 Screen b: 0 Drill yr: 1966 Drill mo: 5 Yield: 400

Yield yr: 1966 G logs: Not Reported

 D logs:
 1
 P test:
 0

 Chem:
 Not Reported
 WI:
 56

Wl yr: 1966 Driller: Ackerman

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000004690

 Map ID:
 4

 Fid:
 4874
 Conum:
 CHN-540

 Fid:
 4874

 Scgrid:
 18CC-g2

 Lat:
 325354

 Lon:
 795813

 Little o:
 506307

 Utm e:
 596307
 Utm n:
 3640296

 Topo:
 North Charleston
 Elev:
 15

Owner well: Not Reported Owner: Westvaco, Inc. Location: N. Charleston Use: IND Depth d: 0 Depth c: 450 Diam 1: 6 Diam 2: 0 Screen t: 450 Oh cas: 0 Screen b: 0 Drill yr: 0 Drill mo: 0 Yield:

Yield yr: 0 G logs: Not Reported D logs: 0 P test: 0

Chem: C WI: Not Reported

Wl yr: 0 Driller: Mixon Filename: Coastal_Plain_wells.xls

SCWC40000004875

 Map ID:
 5

 Fid:
 3396
 Conum:
 BRK-297

 Scgrid:
 18CC-i1

 Lat:
 325321

 Lon:
 795604

Site id:

 Utm e:
 599669
 Utm n:
 3639313

 Topo:
 North Charleston
 Elev:
 25

Owner well: Owner: George Detyen Not Reported Location: Not Reported Use: DOM 0 Depth c: Depth d: 341 4 Diam 2: 0 Diam 1:

 Oh cas:
 145
 Screen t:
 0

 Screen b:
 0
 Drill yr:
 1980

 Drill mo:
 8
 Yield:
 0

 Viold yr:
 0
 O logge:
 Not Pe

Yield yr: 0 G logs: Not Reported

D logs: 1 P test: 0

Chem: Not Reported WI: Not Reported WI yr: 0 Driller: Ackerman

Filename: Coastal_Plain_wells.xls Site id: SCWC40000003397

 Map ID:
 6

 Fid:
 4533
 Conum:
 CHN-49

Fid: 4533 Conum: CHN-49
Scgrid: 18CC-g1
Lat: 325308

Lon: 795838 Utm e: 595671 Utm n: 3638873

Topo: North Charleston Elev: 30
Owner: Raybestos-Manhattan Owner well: Not Reported

Location: Not Reported Use: IND Depth d: Depth c: 440 515 Diam 1: Diam 2: 0 8 Oh cas: 308 Screen t: 0 Screen b: 0 Drill yr: 1951 Drill mo: 11 Yield: 440 Yield yr: 1961 G logs: Е P test: D logs: 1

 Chem:
 C
 WI:
 Not Reported

 WI yr:
 0
 Driller:
 Layne-Atlantic

Wl yr: 0 Driller: Layne-Atlantic Filename: Coastal_Plain_wells.xls Site id: SCWC4000004534

Map ID: 7

 Fid:
 5172
 Conum:
 CHN-959

 Scgrid:
 19CC-k1

 Lat:
 325255

800059

Lon:

Site id:

 Utm e:
 592011
 Utm n:
 3638437

 Topo:
 Ladson
 Elev:
 0

Owner: Knight's Redi-Mix Owner well: Not Reported Location: North Charleston Use : IND

Use: Depth c: 330 Depth d: 330 Diam 1: 6 Diam 2: 0 159 0 Oh cas: Screen t: 0 Screen b: Drill yr: 2006 Drill mo: 8 Yield: 250

Yield yr: 2006 G logs: Not Reported

 D logs:
 1
 P test:
 0

 Chem:
 Not Reported
 WI:
 51

 WI vr.
 2006
 Priller:
 Sonders

Wl yr: 2006 Driller: Sanders
Filename: Coastal_Plain_wells.xls

SCWC40000005173

 Map ID:
 8

 Fid:
 4828
 Conum:
 CHN-460

Scgrid: 18CC-o1 Lat: 325254 Lon: 795919 Utm e: 594610

 Utm e:
 594610
 Utm n:
 3638431

 Topo:
 North Charleston
 Elev:
 30

 Owner:
 J. T. Bunn
 Owner well:
 Not Reported

UNU Location: N. Charleston Use: Depth d: 0 Depth c: 325 Diam 1: 4 Diam 2: 0 Oh cas: 126 Screen t: 0 Screen b: 0 Drill yr: 1965 Drill mo: 2 Yield: 73 1965 G, C Yield yr: G logs: P test: D logs: 0 1 Chem: Not Reported WI: 51

Wl yr: 1981 Driller: Ackerman

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000004829

 Map ID:
 9

 Fid:
 3673
 Conum:
 BRK-677

Scgrid: 18CC-m1
Lat: 325230
Lon: 795730
Utm e: 597449

 Utm e:
 597449
 Utm n:
 3637720

 Topo:
 North Charleston
 Elev:
 0

Owner well: Not Reported Owner: U.S. Navy Location: Clouter Island Use: IND Depth d: 342 Depth c: 342 Diam 1: 8 Diam 2: 0 Screen t: 0 Oh cas: 168 0 1989 Screen b: Drill yr: Drill mo: 5 Yield: 330

Yield yr: 1989 G logs: Not Reported

D logs: 1 P test: 1
Chem: Not Reported WI: 41

SCWC40000003674

Chem: Not Reported WI: 41

Wl yr: 1989 Driller: Ackerman Remarks: Used to cool booster pump.
Filename: Coastal_Plain_wells.xls

 Map ID:
 10

 Fid:
 3666
 Conum:
 BRK-670

 Fid:
 3666

 Scgrid:
 18CC-l1

 Lat:
 325230

 Lon:
 795601

Site id:

 Utm e:
 599762
 Utm n:
 3637743

 Topo:
 North Charleston
 Elev:
 0

Owner: Scotty Mill Owner well: Not Reported DOM Wando, 8 miles SW Location: Use: Depth d: 300 Depth c: 300 Diam 1: 4 Diam 2: 0

Oh cas: 170 Screen t: 0 Screen b: 0 Drill yr: 2005 Drill mo: 11 Yield: 100 Yield yr: Not Reported 2005 G logs:

 D logs:
 1
 P test:
 0

 Chem:
 Not Reported
 WI:
 37

 WI yr:
 2005
 Driller:
 Sanders

Filename: Coastal_Plain_wells.xls Site id: SCWC4000003667

 Map ID:
 11

 Fid:
 3395
 Conum:
 BRK-293

Scgrid: 17CC-o1
Lat: 325228
Lon: 795448
Utm e: 601660

 Utm e:
 601660
 Utm n:
 3637701

 Topo:
 Charleston
 Elev:
 10

Owner:Guggenheim FoundationOwner well:Not ReportedLocation:Daniel IslandUse:ABNDepth d:0Depth c:70

Diam 1: 4 Diam 2: 0 Oh cas: 0 Screen t: 0 0 Screen b: 0 Drill yr: Drill mo: 0 Yield: 0 Yield yr: 0 G logs: G, C D logs: P test: 0

Chem: Not Reported WI: Not Reported WI yr: 0 Driller: Not Reported

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000003396

Map ID: 12

Conum:

 Fid:
 3386

 Scgrid:
 18CC-k1

 Lat:
 325226

 Lon:
 795556

 Utm e:
 599894
 Utm n:
 3637621

 Topo:
 Charleston
 Elev:
 5

Owner: M. B. Burns Owner well: Not Reported Location: Not Reported Use: Not Reported

Depth c: Depth d: 0 15 Diam 1: 0 Diam 2: 0 0 0 Oh cas: Screen t: 0 Screen b: 0 Drill yr: Drill mo: 0 Yield: 0

Yield yr: 0 G logs: Not Reported

 D logs:
 0
 P test:
 0

 Chem:
 C
 WI:
 Not Reported

 William
 Not Reported

Wl yr: 0 Driller: Not Reported Filename: Coastal_Plain_wells.xls

Site id: SCWC40000003387

BRK-273

 Map ID:
 13

 Fid:
 3690
 Conum:
 BRK-694

 Scgrid:
 18CC-l2

 Lat:
 325215

 Lon:
 795610

 Utm e:
 599533

 Utm e:
 599533
 Utm n:
 3637279

 Topo:
 Charleston
 Elev:
 0

 Owner:
 Leroy Mitchell
 Owner well:
 Not Reported

DOM Location: Thomas Island on Clouter Creek Use: Depth d: 320 Depth c: 320 Diam 1: 4 Diam 2: 0 Oh cas: 139 Screen t: 0 Screen b: 0 Drill yr: 1990 Drill mo: Yield: 100 1 1990

Yield yr:1990G logs:Not ReportedD logs:1P test:0Chem:Not ReportedWI:52

Chem: Not Reported WI: 52
WI yr: 1990 Driller: Sanders
Filename: Coastal_Plain_wells.xls

SCWC40000003691

Map ID: 14 Fid: 3637 Conum: BRK-641

 Fid:
 3637

 Scgrid:
 18CC-k3

 Lat:
 325213

 Lon:
 795525

 Utm e:
 600703

Site id:

 Utm e:
 600703
 Utm n:
 3637229

 Topo:
 Charleston
 Elev:
 5

Not Reported Robert Shaw Owner well: Owner: Location: Thomas Island Use: Not Reported Depth d: 0 Depth c: 300 0 Diam 1: 0 Diam 2: Screen t: 0 Oh cas: 0

 Diam 1:
 0
 Diam 2:
 0

 Oh cas:
 0
 Screen t:
 0

 Screen b:
 0
 Drill yr:
 0

 Drill mo:
 0
 Yield:
 100

 Yield yr:
 0
 G logs:
 Not Reported

 D logs:
 0
 P test:
 0

 Chem:
 C
 WI:
 Not Reported

 WI yr:
 0
 Driller:
 Not Reported

Remarks: NAWQA well.

Filename: Coastal_Plain_wells.xls Site id: SCWC4000003638

Map ID: 15 Fid: 4841 Conum: CHN-476

Fid: 4841
Scgrid: 18CC-q1
Lat: 325143
Lon: 795811
Utm e: 596398

 Utm e:
 596398
 Utm n:
 3636262

 Topo:
 Charleston
 Elev:
 20

Owner: U. S. Naval Shipyard Owner well: Not Reported UNU Location: N. Charleston Use: Depth d: 0 Depth c: 315 Diam 2: Diam 1: 6 0

Oh cas: 115 Screen t: 0 Screen b: 0 Drill yr: 0 0 Drill mo: 0 Yield: Yield yr: 0 G, C G logs: D logs: 0 P test: 0

Chem: Not Reported WI: Not Reported WI yr: Driller: Not Reported

Filename: Coastal_Plain_wells.xls SCWC40000004842 Site id:

Map ID: 16 3394 BRK-290 Fid: Conum:

Scgrid: 17CC-p3 325129 Lat: Lon: 795447

795741

Lon:

Utm n: 601705 3635884 Utm e: Topo: Charleston Elev:

Owner: Cainhoy Plantation Owner well: Not Reported DOM Location: Daniel Island Use: Depth d: Depth c: 391 0 Diam 1: 4 Diam 2: 0 Oh cas: 148 Screen t: 0 Screen b: 0 Drill yr: 1973

Drill mo: 8 Yield: 80 Not Reported

Yield yr: 1973 G logs: P test: D logs: 0 1 Chem: Not Reported WI: 40

WI yr: 1973 Driller: Ackerman

Coastal_Plain_wells.xls Filename: SCWC40000003395 Site id:

Map ID: 18

Fid: 4513 Conum: CHN-2 Scgrid: 18CC-r1 325121 Lat:

Utm e: 597185 Utm n: 3635592 Topo: Charleston Elev: 12

Owner: Charleston Naval Shipyard Owner well: Not Reported Not Reported IND Location: Use:

Depth c: 2026 Depth d: 2136 Diam 1: 18 Diam 2: 8 0 1736 Oh cas: Screen t: Screen b: 2026 Drill yr: 1943 Drill mo: 3 Yield: 500 Yield yr: 1966 G logs: G, T, D logs: P test:

С +100 Chem: WI: WI yr: Driller: Layne-Atlantic 1966

Filename: Coastal_Plain_wells.xls Site id: SCWC40000004514

 Map ID:
 21

 Fid:
 4602
 Conum:
 CHN-151

Scgrid: 18CC-y1 Lat: 325044 Lon: 795948 Utm e: 593894

 Utm e:
 593894
 Utm n:
 3634421

 Topo:
 Charleston
 Elev:
 25

 Oursell:
 Not Peace.
 Not Peace.

Owner: Jenkins Orphanage Owner well: Not Reported ABN Location: Not Reported Use: Depth d: 0 Depth c: 400 Diam 1: 4 0 Diam 2: Oh cas: 55 Screen t: 0 Screen b: 0 Drill yr: 0 0 Drill mo: Yield: 0

Yield yr: 0 G logs: Not Reported D logs: 0 P test: 0

Chem: Not Reported WI: 18
WI yr: 1967 Driller: Palmetto

Filename: Coastal_Plain_wells.xls Site id: SCWC40000004603

Map ID: 22 Fid: 3392 Conum: BRK-284

 Scgrid:
 17CC-y1

 Lat:
 325038

 Lon:
 795412

 Utm e:
 602631

 Utm e:
 602631
 Utm n:
 3634323

 Topo:
 Charleston
 Elev:
 10

Guggenheim Foundation Owner well: Not Reported Owner: Location: Daniel Island Use: ABN Depth d: 0 Depth c: 82 Diam 1: 6 Diam 2: 0 Screen t: 0 Oh cas: 0 Screen b: 0 Drill yr: 0 0 Drill mo: 0 Yield: Yield yr: 0 G logs: С D logs: 0 P test:

Chem: Not Reported WI: Not Reported WI yr: O Driller: Not Reported

Wl yr: 0 Driller: Not Reported Filename: Coastal_Plain_wells.xls

SCWC40000003393

Map ID: 23

Conum:

 Fid:
 3393

 Scgrid:
 17CC-y2

 Lat:
 325037

 Lon:
 795418

 Utm e:
 602475

Site id:

 Utm e:
 602475
 Utm n:
 3634290

 Topo:
 Charleston
 Elev:
 10

Owner well: Owner: Guggenheim Foundation Not Reported Location: Daniel Island Use: ABN Depth c: 82 Depth d: 0 6 Diam 2: 0 Diam 1:

BRK-285

Oh cas: 0 Screen t: 0 Screen b: 0 Drill yr: 0 0 0 Drill mo: Yield: G Yield yr: 0 G logs: D logs: 0 0 P test:

Chem: Not Reported WI: Not Reported WI yr: O Driller: Not Reported

Filename: Coastal_Plain_wells.xls Site id: SCWC40000003394

 Map ID:
 24

 Fid:
 4575
 Conum:
 CHN-108

Scgrid: 19CC-u2 Lat: 325025 Lon: 800017

 Utm e:
 593146
 Utm n:
 3633829

 Topo:
 Johns Island
 Elev:
 13

Owner: Bird & Sons Owner well: Not Reported IND Location: Charleston Heights Use: Depth d: Depth c: 450 0 Diam 1: 10 Diam 2: 0 Oh cas: 0 Screen t: 0

 Oh cas:
 0
 Screen t:
 0

 Screen b:
 0
 Drill yr:
 1954

 Drill mo:
 0
 Yield:
 213

Yield yr: 1964 G logs: Not Reported

D logs: 0 P test: 0

 $\begin{array}{cccccc} \text{Chem:} & & \text{C} & & \text{WI:} & & \text{Not Reported} \\ \text{WI yr:} & & 0 & & \text{Driller:} & & \text{Connelly} \\ \end{array}$

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000004576

Map ID: 25 Fid: 4574 Conum: CHN-107

 Scgrid:
 19CC-u1

 Lat:
 325023

 Lon:
 800021

Site id:

 Utm e:
 593042
 Utm n:
 3633766

 Topo:
 Johns Island
 Elev:
 13

 Owner:
 Bird & Sons
 Owner well:
 Not Reported

 Location:
 Charleston Heights
 Use:
 IND

 Depth d:
 0
 Depth c:
 450

 Diam 1:
 10
 Diam 2:
 0

Diam 1: 10 Diam 2: 0 120 0 Oh cas: Screen t: 0 Screen b: Drill yr: 1954 Drill mo: 0 Yield: 350 Yield yr: 1963 G logs: G D logs: 0 P test:

Chem:CWI:Not ReportedWI yr:0Driller:Connelly

Wl yr: 0 Driller: Connelly Filename: Coastal_Plain_wells.xls

SCWC40000004575

 Map ID:
 26

 Fid:
 4896
 Conum:
 CHN-607

 Scgrid:
 18CC-v1

 Lat:
 325015

 Lon:
 795651

 Utm e:
 598504

 Utm e:
 598504
 Utm n:
 3633572

 Topo:
 Charleston
 Elev:
 12

 Owner:
 McAlloy Corp.
 Owner well:
 Not Repo

Not Reported Location: Charleston IND Use: Depth d: 495 Depth c: 394 Diam 1: 10 Diam 2: 0 Oh cas: 0 Screen t: 312 Screen b: 394 Drill yr: 1987 Drill mo: 10 Yield: 300 G logs: 0 Е Yield yr: 0 P test: 0 D logs: Chem: С WI: 3

Wl yr: 1987 Driller: Ackerman

Filename: Coastal_Plain_wells.xls Site id: SCWC40000004897

Map ID: 27 Fid: 4899 Conum: CHN-610

Fid: 4899
Scgrid: 18CC-w1
Lat: 325009
Lon: 795713
Utm e: 59734

 Utm e:
 597934
 Utm n:
 3633382

 Topo:
 Charleston
 Elev:
 10

 Owner:
 McAlloy Corp.
 Owner well:
 Not Reported

Location: Charleston Use: IND Depth d: 440 Depth c: 399 Diam 1: 4 Diam 2: 0 50 Screen t: 0 Oh cas: Screen b: 0 Drill yr: 1987 Drill mo: 4 Yield: 0 Yield yr: 0 G logs: E, G D logs: 0 P test:

Chem: Not Reported WI: Not Reported
Wl vr: Not Reported

Wl yr: 0 Driller: Not Reported Filename: Coastal_Plain_wells.xls

Site id: SCWC40000004900

 Map ID:
 28

 Fid:
 4875
 Conum:
 CHN-541

Scgrid: 17DD-d3
Lat: 324948
Lon: 795324
Ltm o: 603895

 Utm e:
 603895
 Utm n:
 3632796

 Topo:
 Charleston
 Elev:
 12

Owner:South Carolina State Ports AuthorOwner well:Not ReportedLocation:Wando TerminalUse:UNUDepth d:0Depth c:329Diam 1:4Diam 2:0

Oh cas: 0 Screen t: 0 Screen b: 0 Drill yr: 0 0 0 Drill mo: Yield: G Yield yr: 0 G logs: 0 D logs: 0 P test:

Chem: Not Reported WI: Not Reported WI yr: 0 Driller: Not Reported

Filename: Coastal_Plain_wells.xls Site id: SCWC40000004876

 Map ID:
 29

 Fid:
 4885
 Conum:
 CHN-582

 Scgrid:
 18DD-b2

 Lat:
 324940

 Lon:
 795650

 Utm e:
 598541
 Utm n:
 3632495

 Topo:
 Charleston
 Elev:
 0

Owner: W. R. Grace Co. Owner well: Not Reported

Location: Fertilizer Plant Use: IND Depth d: Depth c: 240 0 Diam 1: 0 Diam 2: 0 Oh cas: 0 Screen t: 0 0 Screen b: 0 Drill yr: Drill mo: 0 Yield: 300

Yield yr: 0 G logs: Not Reported

D logs: 0 P test: 0

Chem: Not Reported WI: Not Reported WI yr: 0 Driller: Not Reported

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000004886

Map ID: 29

Fid: 4886 Conum: CHN-583 Scgrid: 18DD-b3 Lat: 324940

795650

Lon:

 Utm e:
 598541
 Utm n:
 3632495

 Topo:
 Charleston
 Elev:
 0

Owner: W. R. Grace Co. Owner well: Not Reported Location: Fertilizer Plant Use: IND

Depth c: 220 Depth d: 0 Diam 1: 0 Diam 2: 0 0 0 Oh cas: Screen t: 0 0 Screen b: Drill yr: Drill mo: 0 Yield: 250

 Yield yr:
 0
 G logs:
 Not Reported

 D logs:
 0
 P test:
 0

Chem: Not Reported WI: Not Reported

Wl yr: 0 Driller: Not Reported

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000004887

 Map ID:
 30

 Fid:
 4591
 Conum:
 CHN-137

Scgrid: 18DD-c1 Lat: 324927 Lon: 795702 Utm e: 598233

 Utm e:
 598233
 Utm n:
 3632091

 Topo:
 Charleston
 Elev:
 15

 Owner:
 Exxon Co.
 Owner well:
 Not Reported

ABN Location: Not Reported Use: Depth d: 510 Depth c: 510 Diam 1: 8 Diam 2: 0 Oh cas: 0 Screen t: 384 Screen b: 505 Drill yr: 1961 400 Drill mo: 4 Yield: 1960 G logs: G, C Yield yr: P test: 0 D logs: 1 Chem: Not Reported WI: 51

Wl yr: 1992 Driller: Ackerman

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000004592

Map ID: 31 Fid: 4590 Conum: CHN-136

Scgrid: 18DD-b1 Lat: 324920 Lon: 795657 Utm e: 598365

 Utm e:
 598365
 Utm n:
 3631877

 Topo:
 Charleston
 Elev:
 15

Owner well: Not Reported Owner: Exxon Co. Location: Not Reported Use: UNU Depth d: 573 Depth c: 504 Diam 1: 8 Diam 2: 0 Oh cas: Screen t: 339 0 Screen b: 504 Drill yr: 1960 Drill mo: 4 Yield: 220 Yield yr: 1977 G logs: G, C, D logs: P test: 0 С Chem: WI: 32

Wl yr: 1982 Driller: Ackerman

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000004591

 Map ID:
 32

 Fid:
 4581
 Conum:
 CHN-115

Scgrid: 17DD-d1
Lat: 324917
Lon: 795356
Utm e: 603073

 Utm e:
 603073
 Utm n:
 3631833

 Topo:
 Charleston
 Elev:
 10

Owner well: Owner: Hobcaw Yacht Club Not Reported Location: Hobcaw Point Use: **REC** Depth c: 350 Depth d: 0 4 Diam 2: 0 Diam 1:

 Oh cas:
 0
 Screen t:
 0

 Screen b:
 0
 Drill yr:
 0

 Drill mo:
 0
 Yield:
 50

Yield yr: 0 G logs: Not Reported

D logs: 0 P test: 0

Chem: C WI: Not Reported WI yr: 0 Driller: Not Reported

Filename: Coastal_Plain_wells.xls Site id: SCWC40000004582

Map ID: 33 Fid: 4687 Conum: CHN-289

 Segrid:
 17DD-f1

 Lat:
 324853

 Lon:
 795414

 Utm e:
 602612
 Utm n:
 3631089

 Topo:
 Charleston
 Elev:
 5

Owner: Longshoremen Assoc. Owner well: Not Reported Location: Scanlonville Use: UNU
Depth d: 0 Depth c: 344

Diam 1: 3 Diam 2: 0 Oh cas: 100 Screen t: 0 0 Screen b: 0 Drill yr: 0 Drill mo: 0 Yield: Yield yr: 0 G logs: E, G P test: D logs: 0

Chem: Not Reported WI: Not Reported WI yr: 0 Driller: Not Reported

Filename: Coastal_Plain_wells.xls

Site id: SCWC40000004688

 Map ID:
 34

 Fid:
 4688
 Conum:
 CHN-292

 Scgrid:
 17DD-g6

 Lat:
 324836

 Lon:
 795324

 Utm e:
 603918
 Utm n:
 3630579

 Topo:
 Charleston
 Elev:
 20

Owner: Greater Holy Trinity AME Church Owner well: Not Reported Location: Not Reported Use: Not Reported Depth d: Depth c: 26

Diam 1: 0 Diam 2: 0 0 0 Oh cas: Screen t: 0 0 Screen b: Drill yr: Drill mo: 0 Yield: 0

Yield yr: 0 G logs: Not Reported

D logs: 0 P test: 0

Chem: Not Reported WI: Not Reported WI yr: O Driller: Not Reported

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000004689

CHN-87

 Map ID:
 35

 Fid:
 4558

 Conum:

 Scgrid:
 17DD-g9

 Lat:
 324829

 Lon:
 795330

 Utm e:
 603764

Site id:

Lon:

 Utm e:
 603764
 Utm n:
 3630362

 Topo:
 Charleston
 Elev:
 24

 Owner:
 Town of Mount Pleasant
 Owner well:
 Not Reported

UNU Location: Not Reported Use: Depth d: 60 Depth c: 60 Diam 1: 8 Diam 2: 0 Oh cas: 0 Screen t: 30 Screen b: 58 Drill yr: 1958 Drill mo: 4 Yield: 50 1958 G logs: Not Reported

 Yield yr:
 1958
 G logs:
 Not Re

 D logs:
 1
 P test:
 0

 Chem:
 Not Reported
 WI:
 9

WI yr: 1958 Driller: Heater Filename: Coastal_Plain_wells.xls

SCWC40000004559

795330

Map ID: 35

 Fid:
 4611
 Conum:
 CHN-167

 Scgrid:
 17DD-g7

 Lat:
 324829

 Utm e:
 603764
 Utm n:
 3630362

 Topo:
 Charleston
 Elev:
 24

 Owner:
 Town of Mount Pleasant
 Owner well:
 Not Reported

 Location:
 Mathis Ferry Rd.
 Use:
 PS

Depth d: 2039 Depth c: 1993 Diam 1: 8 Diam 2: 0 Oh cas: Screen t: 1800 0 Screen b: 1986 Drill yr: 1969 2000 Drill mo: 7 Yield: Yield yr: 1995 G logs: E, G D logs: P test: 1 С Chem: WI: 59

Wl yr: 1990 Driller: Layne-Atlantic

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000004612

 Map ID:
 35

 Fid:
 4603
 Conum:
 CHN-152

 Scgrid:
 17DD-g8

 Lat:
 324829

 Lon:
 795329

 Itm e:
 603700

 Utm e:
 603790
 Utm n:
 3630362

 Topo:
 Charleston
 Elev:
 24

Owner well: Owner: Town of Mount Pleasant Not Reported Location: Mathis Ferry Rd. Use: ABN Depth c: Depth d: 0 515 10 Diam 2: 0 Diam 1:

Oh cas: 89 Screen t: 0 Screen b: 0 Drill yr: 1967 Drill mo: 6 Yield: 250 Yield yr: 1967 G logs: E, G, D logs: P test: 1 1 С 49 Chem: WI: WI yr: 1991 Driller: Ackerman

Filename: Coastal_Plain_wells.xls SCWC40000004604 Site id:

Map ID: 35 4561 CHN-90 Fid: Conum:

Scgrid: 17DD-g10 324829 Lat: Lon: 795327 603842 Utm e:

Utm n: 3630362 Topo: Charleston Elev:

Owner: Town of Mount Pleasant Owner well: Not Reported UNU Location: Not Reported Use: Depth d: Depth c: 55 120 Diam 1: 8 Diam 2: 0 Oh cas: 0 Screen t: 20 1958 Screen b: 52 Drill yr: Drill mo: 4 Yield: 40

Yield yr: 1958 G logs: Not Reported

P test: D logs: 0 1 Chem: Not Reported WI: Heater

WI yr: 1958 Driller: Coastal_Plain_wells.xls Filename: SCWC40000004562

Map ID: 35

Conum:

Fid: 4557 17DD-g11 Scgrid: 324828 Lat: 795328 Lon: Utm e: 603817

Site id:

Utm n: 3630331 Topo: Charleston Elev:

Not Reported Owner: Town of Mount Pleasant Owner well: UNU Not Reported Location: Use: Depth d:

48 60 Depth c: Diam 1: 8 Diam 2: 0 0 22 Oh cas: Screen t: 43 Screen b: Drill yr: 1958 3 Drill mo: Yield: 200

Yield yr: 1958 G logs: Not Reported D logs: P test:

9 Chem: Not Reported WI: WI yr: Driller: 1958 Heater

Coastal_Plain_wells.xls Filename: Site id: SCWC40000004558

CHN-86

Utm n:

Map ID: 36 Fid: 5088 Conum: CHN-875

17DD-g14 Scgrid: 324827 Lat: 795333 Lon: 603687 Utm e:

Topo: Charleston Elev: 20 Owner: Town of Mount Pleasant Owner well: Not Reported

TEST Location: 1 1/2 miles NW of town center Use: 1355 Depth d: 1500 Depth c: Diam 1: 6 Diam 2: Oh cas: 0 Screen t: 1165 Screen b: 1355 Drill yr: 2005 Drill mo: 9 Yield: 160 2005 G logs: E, G, Yield yr: P test: D logs: 0 1 Chem: С WI: 12 WI yr: 2005 Driller: Layne

Filename: Coastal_Plain_wells.xls SCWC4000005089 Site id:

Map ID: 37 4562 CHN-91 Fid: Conum:

17DD-g1 Scgrid: Lat: 324826 795325 Lon: Utm e: 603895

Utm n: 3630271 Topo: Charleston Elev: 20 Town of Mount Pleasant Owner well: Not Reported Owner:

Location: Not Reported Use: UNU Depth d: 65 Depth c: 44 0 Diam 1: 8 Diam 2: 0 Screen t: 29 Oh cas: Screen b: 39 Drill yr: 1961 Drill mo: 8 Yield: 75

Not Reported Yield yr: 1961 G logs: D logs: 1 P test:

Р Chem: WI: 12

WI yr: 1961 Driller: Layne-Atlantic

Filename: Coastal_Plain_wells.xls

Site id: SCWC40000004563

Map ID: 36 4560 CHN-89 Fid: Conum:

17DD-g12 Scgrid: 324825 Lat: Lon: 795330

Utm n: 3630238 Utm e: 603766 Topo: Charleston Elev: 22

Town of Mount Pleasant Owner well: Owner: Not Reported UNU Location: Not Reported Use: Depth c: Depth d: 48 44 0 8 Diam 2: Diam 1:

Oh cas: 0 Screen t: 20 Screen b: 42 Drill yr: 1958 Drill mo: 4 Yield: 150 Yield yr: Not Reported 1958 G logs:

 D logs:
 1
 P test:
 0

 Chem:
 Not Reported
 WI:
 9

 WI yr:
 1958
 Driller:
 Heater

Filename: Coastal_Plain_wells.xls Site id: SCWC4000004561

Map ID: 37 Fid: 4563 Conum: CHN-92

Scgrid: 17DD-g5 Lat: 324825 Lon: 795323

 Utm e:
 603948
 Utm n:
 3630240

 Topo:
 Charleston
 Elev:
 20

Owner: Town of Mount Pleasant Owner well: Not Reported UNU Location: Not Reported Use: Depth d: Depth c: 44 65 Diam 1: 8 Diam 2: 0 Oh cas: Screen t:

 Oh cas:
 0
 Screen t:
 29

 Screen b:
 39
 Drill yr:
 1961

 Drill mo:
 8
 Yield:
 75

Yield yr: 1961 G logs: Not Reported

 D logs:
 1
 P test:
 1

 Chem:
 P
 WI:
 10

Wl yr: 1961 Driller: Layne-Atlantic

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000004564

Map ID: 36

Fid: 4559 Conum: CHN-88 Scgrid: 17DD-g13 Lat: 324824

 Lon:
 795331

 Utm e:
 603740
 Utm n:
 3630207

 Topo:
 Charleston
 Elev:
 22

Owner: Town of Mount Pleasant Owner well: Not Reported Location: Not Reported Use: UNU

Depth d: 50 Depth c: 45

Diam 1: 8 Diam 2: 0 0 20 Oh cas: Screen t: 42 Screen b: Drill yr: 1958 Drill mo: 4 Yield: 75

Yield yr: 1958 G logs: Not Reported

 D logs:
 1
 P test:
 0

 Chem:
 Not Reported
 WI:
 9

 WII:
 Polllary:
 Understanding

Wl yr: 1958 Driller: Heater Filename: Coastal_Plain_wells.xls

SCWC40000004560

Site id:

CHN-95

Map ID: 38 Fid: 4566 Conum:

17DD-g4 Scgrid: 324822 Lat: 795328 Lon: 603819 Utm e:

3630147 Utm n: Topo: Charleston Elev: 20 Owner: Town of Mount Pleasant Owner well: Not Reported

UNU Location: Not Reported Use: Depth d: 65 Depth c: 49 Diam 1: 8 0 Diam 2: Oh cas: 0 Screen t: 21 Screen b: 44 Drill yr: 1961 8 Drill mo: Yield: 75

G logs: 1961 Not Reported Yield yr: P test: D logs: 1 1

Chem: Ρ WI:

WI yr: 1961 Driller: Layne-Atlantic

Coastal_Plain_wells.xls Filename: SCWC40000004567 Site id:

Map ID: 39 4564 CHN-93 Fid: Conum:

17DD-g3 Scgrid: Lat: 324822 795321 Lon: Utm e: 604001

Utm n: 3630149 Topo: Charleston Elev: 20 Town of Mount Pleasant Not Reported Owner well: Owner:

Location: Not Reported Use: UNU Depth d: 65 Depth c: 50 Diam 1: 8 Diam 2: 0 Screen t: Oh cas: 0 17 Screen b: Drill yr: 45 1961 Drill mo: 8 Yield: 70

Yield yr: 1961 G logs: Not Reported D logs: 1 P test:

Р Chem: WI: 4

Layne-Atlantic WI yr: 1961 Driller:

Filename: Coastal_Plain_wells.xls

Site id: SCWC40000004565

Map ID: 38 4565 CHN-94 Fid: Conum:

17DD-g2 Scgrid: 324821 Lat: Lon: 795326

Utm n: 3630116 Utm e: 603871 Topo: Charleston Elev: 20

Town of Mount Pleasant Owner well: Owner: Not Reported UNU Location: Not Reported Use: Depth c: Depth d: 65 50 8 Diam 2: 0 Diam 1:

Oh cas: 0 Screen t: 17 Screen b: 45 Drill yr: 1961 Drill mo: 8 Yield: 75 Yield yr: Not Reported 1961 G logs:

 D logs:
 1
 P test:
 1

 Chem:
 P
 WI:
 2

Wl yr: 1961 Driller: Layne-Atlantic

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000004566

Map ID: 40 Fid: 4520 Conum: CHN-13

 Fid:
 4520
 Conum:
 CHN-13

 Scgrid:
 18DD-i1

 Lat:
 324808

 Lon:
 795635

 Utm e:
 598960
 Utm n:
 3629666

 Topo:
 Charleston
 Elev:
 10

Owner: City of Charleston Owner well: Not Reported **FIRE** Location: Nassau St. Use: Depth d: Depth c: 2000 0 Diam 1: 0 Diam 2: 0 Oh cas: 0 Screen t: 0 Screen b: 0 Drill yr: 1897

Drill mo: 0 Yield: 0

Yield yr: 0 G logs: Not Reported D logs: 0 P test: 0

Chem: Not Reported WI: Flow WI vr. 0 Driller Miller

Wl yr: 0 Driller: Miller

Remarks: Open-hole well.
Filename: Coastal_Plain_wells.xls

SCWC40000004521

Site id:

Map ID: 41

 Fid:
 4519
 Conum:
 CHN-12

 Scgrid:
 18DD-12

 Lat:
 324758

Lon: 795623 Utm e: 599275 Utm n: 3629361

Topo:CharlestonElev:10Owner:City of CharlestonOwner well:Not ReportedLocation:Hanover St.Use:REC

Use: Depth d: 0 Depth c: 1945 20 6 Diam 1: Diam 2: 0 Screen t: 0 Oh cas: 0 Screen b: Drill yr: 1885 Drill mo: 0 Yield: 700 Yield yr: 1960 G logs: C, T, D logs: 0 P test: 0

 Dilogs.
 O
 Flow

 Chem:
 C
 WI:
 Flow

 WI yr:
 1960
 Driller:
 Gray

Remarks: No info on screen.

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000004520

Map ID: 43 Fid: 4512 Conum: CHN-1

 Scgrid:
 18DD-k20

 Lat:
 324730

 Lon:
 795525

 Utm e:
 600792

 Utm e:
 600792
 Utm n:
 3628514

 Topo:
 Charleston
 Elev:
 5

Owner: Charleston Consolidated Railway Swner well: Not Reported ABN Location: Charlotte St. near Cooper River Use: Depth d: Depth c: 2001 Diam 1: 10 Diam 2: 6 Oh cas: 0 Screen t: 0 Screen b: 0 Drill yr: 1911 Drill mo: 5 Yield: 429

Yield yr: 0 G logs: Not Reported

 D logs:
 0
 P test:
 0

 Chem:
 Not Reported
 WI:
 +75

 WI yr:
 1911
 Driller:
 Hendricks

Remarks: See L. W. Stephenson report of 1914. Geol. log.

Filename: Coastal_Plain_wells.xls Site id: SCWC40000004513

Map ID: 44 Fid: 4521 Conum: CHN-14

Fid: 4521 Scgrid: 18DD-k3 Lat: 324729 Lon: 795543 Utm e: 600324

 Utm e:
 600324
 Utm n:
 3628478

 Topo:
 Charleston
 Elev:
 5

Owner: S. C. Electric & Gas Owner well: Not Reported Location: Charlotte St. at Cooper River Use: DES 2001 Depth d: Depth c: Diam 1: Diam 2: 14 6 Oh cas: 1875 Screen t: 0 Screen b: 0 Drill yr: 1911 Drill mo: 0 Yield: 429 Yield yr: 1946 G logs: G, C, D logs: 0 P test: 0

Chem: Not Reported WI: 75
WI yr: 1946 Driller: Not Reported

 WI yr:
 1946
 Driller:

 Filename:
 Coastal_Plain_wells.xls

 Site id:
 SCWC40000004522

Map ID: 45 Fid: 5032 Conum: CHN-776

Scgrid: 18DD-k10
Lat: 324727
Lon: 795536

 Utm e:
 600507
 Utm n:
 3628419

 Topo:
 Charleston
 Elev:
 6

Owner: National Park Service Owner well: Not Reported OBS Location: Not Reported Use: Depth d: Depth c: 15 15 Diam 1: 2 Diam 2: 0

 Oh cas:
 0
 Screen t:
 3

 Screen b:
 13
 Drill yr:
 1992

 Drill mo:
 8
 Yield:
 0

 Viold yr:
 0
 O logs:
 Not Be

Yield yr: 0 G logs: Not Reported

 D logs:
 0
 P test:
 0

 Chem:
 Not Reported
 WI:
 3

Wl yr: Not Reported WI: 3
Wl yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000005033

 Map ID:
 45

 Fid:
 5026
 Conum:
 CHN-770

Scgrid: 18DD-k4
Lat: 324726
Lon: 795538

Utm e: 600455 Utm n: 3628387

Topo: Charleston Elev: 6

Owner:National Park ServiceOwner well:Not ReportedLocation:Not ReportedUse:OBSDepth d:12Depth c:12

Diam 1: 2 Diam 2: 0 Oh cas: 0 Screen t: 3 1992 Screen b: 10 Drill yr: Drill mo: 8 Yield: 0

Yield yr: 0 G logs: Not Reported

D logs: 0 P test: 0
Cham: Not Paparted With 3

Chem: Not Reported WI: 3

Wl yr: 1992 Driller: Gen. Engr. Filename: Coastal_Plain_wells.xls

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000005027

 Map ID:
 45

 Fid:
 5036
 Conum:
 CHN-780

 Sogrid:
 18DD-k14

 Lat:
 324726

 Lon:
 795535

 Utm e:
 600533

 Utm n:

 Utm e:
 600533
 Utm n:
 3628388

 Topo:
 Charleston
 Elev:
 6

Topo: Charleston Elev: 6
Owner: National Park Service Owner well: Not Reported

Not Reported OBS Location: Use: Depth c: 27 Depth d: 27 Diam 1: 2 Diam 2: 0 0 10 Oh cas: Screen t: Screen b: 25 Drill yr: 1992 8 Drill mo: Yield:

Yield yr: 0 G logs: Not Reported

 D logs:
 0
 P test:
 0

 Chem:
 Not Reported
 WI:
 3

Wl yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000005037

Utm n:

Conum:

 Map ID:
 45

 Fid:
 5034
 Conum:
 CHN-778

 Scgrid:
 18DD-k12

 Lat:
 324726

 Lon:
 795534

 Utm e:
 600559

Topo: Charleston Elev: 7

Owner: National Park Service Owner well: Not Reported Location: Not Reported Use: ORS

OBS Location: Not Reported Use: Depth d: 20 Depth c: 20 Diam 1: 2 0 Diam 2: Oh cas: 0 Screen t: 4 Screen b: 18 Drill yr: 1992 Drill mo: 8 Yield: 0

Yield yr: 0 G logs: Not Reported D logs: 0 P test: 0

Chem: Not Reported WI: 4

Wl yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000005035

Map ID: 45

 Fid:
 5027

 Scgrid:
 18DD-k5

 Lat:
 324725

 Lon:
 795538

 Utm e:
 600455

 Utm e:
 600455
 Utm n:
 3628356

 Topo:
 Charleston
 Elev:
 6

Owner: National Park Service Owner well: Not Reported

Location: Not Reported Use: OBS Depth d: 12 Depth c: 12 0 Diam 1: 2 Diam 2: Oh cas: Screen t: 3 0 Screen b: Drill yr: 1992 10 Drill mo: 8 Yield:

Yield yr: 0 G logs: Not Reported D logs: 0 P test: 0

 D logs:
 0
 P test:
 0

 Chem:
 Not Reported
 WI:
 4

Wl yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000005028

 Map ID:
 45

 Fid:
 5031
 Conum:
 CHN-775

 Scgrid:
 18DD-k9

 Lat:
 324725

 Lon:
 795537

 Ltm o:
 600481

 Utm e:
 600481
 Utm n:
 3628357

 Topo:
 Charleston
 Elev:
 6

Owner well: Owner: National Park Service Not Reported Location: Not Reported Use: OBS Depth c: Depth d: 15 15 2 Diam 2: 0 Diam 1:

3628388

CHN-771

 Oh cas:
 0
 Screen t:
 3

 Screen b:
 13
 Drill yr:
 1992

 Drill mo:
 8
 Yield:
 0

 Viold yr:
 0
 O logs:
 Not Be

Yield yr: 0 G logs: Not Reported D logs: 0 P test: 0

 D logs:
 0
 P test:
 0

 Chem:
 Not Reported
 WI:
 3

Wl yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls Site id: SCWC4000005032

Topo:

Site id:

Map ID: 45

 Fid:
 5038
 Conum:
 CHN-782

 Scgrid:
 18DD-k16

Lat: 324725 Lon: 795533 Utm e: 600586 Utm n:

Charleston

Owner: USGS Owner well: Not Reported Location: Not Reported Use: Not Reported

Elev:

Location: Not Reported Use: Depth d: Depth c: 0 0 Diam 1: 0 Diam 2: 0 Oh cas: 0 Screen t: 0 0 Screen b: 0 Drill yr:

 Drill mo:
 0
 Yield:
 0

 Yield yr:
 0
 G logs:
 Not Reported

D logs: 0 P test: 0

Chem: Not Reported WI: Not Reported

Wl yr: 0 Driller: Not Reported

Filename: Coastal_Plain_wells.xls
Site id: SCWC4000005039

 Map ID:
 45

 Fid:
 5028
 Conum:
 CHN-772

Scgrid: 18DD-k6
Lat: 324724

 Lon:
 795538

 Utm e:
 600456

 Utm n:
 3628326

Topo: Charleston Elev: 6
Owner: National Park Service Owner well: Not Reported

OBS Not Reported Location: Use: Depth c: Depth d: 16 16 Diam 1: 2 Diam 2: 0 0 3 Oh cas: Screen t: Screen b: 14 Drill yr: 1992 Drill mo: 8 Yield:

Yield yr: 0 G logs: Not Reported

D logs: 0 P test: 0

Chem: Not Reported WI: 4

SCWC4000005029

Wl yr: 1993 Driller: Gen. Engr. Filename: Coastal_Plain_wells.xls

 Map ID:
 45

 Fid:
 5040
 Conum:
 CHN-784

 Scgrid:
 18DD-k18

 Lat:
 324724

 Lon:
 795537

 Utm e:
 600482

 Utm e:
 600482
 Utm n:
 3628326

 Topo:
 Charleston
 Elev:
 0

 Owner:
 USGS
 Owner well:
 Not Reported

 Location:
 Not Reported
 Use :
 Not Reported

 Depth d:
 0
 Depth c:
 0

 Diam 1:
 0
 Diam 2:
 0

 Oh cas:
 0
 Screen t:
 0

 Dlam 1:
 0
 Dlam 2:
 0

 Oh cas:
 0
 Screen t:
 0

 Screen b:
 0
 Drill yr:
 0

 Drill mo:
 0
 Yield:
 0

 Yield yr:
 0
 G logs:
 Not

Yield yr: 0 G logs: Not Reported D logs: 0 P test: 0

Chem: Not Reported WI: Not Reported WI vr: 0 Driller: Not Reported

Wl yr: 0 Driller: Not Reported Filename: Coastal_Plain_wells.xls
Site id: SCWC4000005041

Map ID: 45 Fid: 5041 Conum: CHN-785

Scgrid: 18DD-k19
Lat: 324724
Lon: 795537
Utm e: 600482

Topo: Charleston Elev: 0
Owner: USGS Owner well: Not Reported

Utm n:

Location: Not Reported Use: Not Reported Depth d: 0 Depth c: 0 Diam 1: 0 Diam 2: Screen t: 0 Oh cas: 0 Screen b: 0 Drill yr: 0 Yield: Drill mo: 0

Yield yr: 0 G logs: Not Reported

D logs: 0 P test: 0
Chem: Not Reported WI: Not Reported

Wl yr: 0 Driller: Not Reported Filename: Coastal_Plain_wells.xls

Site id: SCWC4000005042

 Map ID:
 45

 Fid:
 5039
 Conum:
 CHN-783

 Scgrid:
 18DD-k17

 Lat:
 324724

 Lon:
 795537

 Utm e:
 600482
 Utm n:
 3628326

 Topo:
 Charleston
 Elev:
 0

Owner: USGS Owner well: Not Reported Location: Not Reported Use: Not Reported

 Depth d:
 0
 Depth c:
 0

 Diam 1:
 0
 Diam 2:
 0

Oh cas: 0 Screen t: 0 Screen b: 0 Drill yr: 0 0 Drill mo: Yield:

0 Not Reported Yield yr: G logs:

D logs: 0 P test:

Chem: Not Reported WI: Not Reported WI yr: Driller: Not Reported

Filename: Coastal_Plain_wells.xls SCWC4000005040 Site id:

Map ID: 45 5029 CHN-773 Fid: Conum:

Scgrid: 18DD-k7 324724 Lat: Lon: 795537

Utm n: 600482 3628326 Utm e:

Topo: Charleston Elev: Owner: National Park Service Owner well:

Not Reported OBS Location: Not Reported Use: Depth d: Depth c: 14 14 Diam 1: 2 Diam 2: 0 Oh cas: 0 Screen t: 2 Screen b: 12 Drill yr: 1992 Drill mo: 8 Yield: 0

Yield yr: 0 G logs: Not Reported

0 P test: D logs: 0 Chem: Not Reported WI: 5

WI yr: 1993 Driller: Gen. Engr.

Coastal_Plain_wells.xls Filename:

SCWC4000005030 Site id:

Map ID: 45 Fid: 5030 Conum: CHN-774

18DD-k8 Scgrid: 324724 Lat: 795537 Lon:

Utm e: 600482 Utm n: 3628326

Topo: Charleston Elev: Owner: National Park Service Owner well: Not Reported OBS Not Reported Location: Use:

Depth d: 16 Depth c: 16 Diam 1: 2 Diam 2: 0 0 4 Oh cas: Screen t: Screen b: 14 Drill yr: 1992 Drill mo: 8 Yield:

Yield yr: 0 G logs: Not Reported

D logs: P test:

5 Chem: Not Reported WI:

WI yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls Site id: SCWC40000005031

Map ID: 45 Fid: 5035 Conum: CHN-779

Scgrid: 18DD-k13 324724 Lat: 795535 Lon: 600534 Utm e:

3628326 Utm n: Topo: Charleston Elev: Owner: National Park Service Owner well: Not Reported

OBS Location: Not Reported Use: Depth d: Depth c: 18 18 Diam 1: 2 Diam 2: 0 Oh cas: 0 Screen t: 3 Screen b: 15 Drill yr: 1992 Drill mo: 8 Yield: 0

0 G logs: Not Reported Yield yr: P test: D logs: 0 0

Chem: Not Reported WI:

WI yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls SCWC4000005036 Site id:

Map ID: 47 5037 CHN-781 Conum:

Fid: 18DD-k15 Scgrid: Lat: 324718 795537 Lon: Utm e: 600484

Utm n: 3628141 Topo: Charleston Elev:

National Park Service Not Reported Owner well: Owner: Location: Not Reported Use: OBS Depth d: 17 Depth c: 17 0 Diam 1: 2 Diam 2: Oh cas: Screen t: 3 0 Screen b: 14 Drill yr: 1992 Drill mo: 8 Yield:

Yield yr: 0 G logs: Not Reported

D logs: 0 P test:

Not Reported Chem: WI: 3 1993 WI yr: Driller:

Gen. Engr. Filename: Coastal_Plain_wells.xls

Site id: SCWC4000005038

Map ID: 47 5033 CHN-777 Fid: Conum:

18DD-k11 Scgrid: 324718 Lat: Lon: 795535

600536 Utm n: 3628142 Utm e: Topo: Charleston Elev:

Owner well: Owner: National Park Service Not Reported Location: Not Reported Use: OBS Depth c: Depth d: 28 28 2 Diam 2: 0 Diam 1:

 Oh cas:
 0
 Screen t:
 14

 Screen b:
 26
 Drill yr:
 1992

 Drill mo:
 8
 Yield:
 0

 Viold yr:
 0
 Close:
 Not Be

Yield yr: 0 G logs: Not Reported

 D logs:
 0
 P test:
 0

 Chem:
 Not Reported
 WI:
 3

Wl yr: 1993 Driller: Gen. Engr.

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000005034

Map ID: 48

 Fid:
 4518
 Conum:
 CHN-11

 Scgrid:
 18DD-11

 Lat:
 324709

 Lon:
 795612

 Utm e:
 599576

 Utm n:
 3627855

Topo:CharlestonElev:10Owner:City of CharlestonOwner well:Not ReportedLocation:Marion SquareUse:UNU

Depth d: Depth c: 1970 0 Diam 1: 0 Diam 2: 0 Oh cas: 0 Screen t: 0 0 Screen b: Drill yr: 1878 Drill mo: 0 Yield: 465

Yield yr: 1878 G logs: Not Reported

D logs: 0 P test: 0
Chem: C WI: +92

Wl yr: 1946 Driller: Not Reported

Filename: Coastal_Plain_wells.xls
Site id: SCWC40000004519

Map ID: 49

Fid: 4540 Conum: CHN-64 Scgrid: 18DD-k2 Lat: 324709

 Lon:
 795559

 Utm e:
 599914
 Utm n:
 3627858

 Topo:
 Charleston
 Elev:
 10

Not Reported City of Charleston Owner: Owner well: UNU George St. Location: Use: Depth c: 1435 Depth d: 0 Diam 1: 8 Diam 2: 0 0 0 Oh cas: Screen t: 0 Screen b: Drill yr: 1900 Drill mo: 0 Yield: 300 Yield yr: 1961 G logs: G, C, D logs: 0 P test:

 Chem:
 C
 WI:
 +71

 WI yr:
 1968
 Driller:
 Not Reported

Remarks: Date drilled approximate.

Filename: Coastal_Plain_wells.xls

SCWC40000004541

Site id:

GEOCHECK VERSION 2.1 PUBLIC WATER SUPPLY SYSTEM INFORMATION

PWS SUMMARY:

Map ID:

PWS Water Well Information:

Epa region: 04 State: SC

Pwsid: SC0860052

Pwsname: CLOVERLEAF MHP

City served:Not ReportedState served:SCZip served:Not ReportedFips county:45015Status:ClosedPop srvd:85

Pwssvcconn:37Source:GroundwaterPws type:CWSOwner:Private

Contact: Not Reported Contactor gname: Not Reported

Contact phone: 843-766-9124 Contact address1: LOUIS DIMUZIO Contact address2: PO BOX 31318 Contact city: CHARLESTON

Contact state: SC Contact zip: 29417

Activity code:

Location Information:

Name: CLOVERLEAF MHP

Pwstypcd: CWS Primsrccd: GW

 Popserved:
 85

 Add1:
 LOUIS DIMUZIO

 Add2:
 PO BOX 31318

City: CHARLESTON State: SC

Zip:29417Phone:843-766-9124Cityserv:Not ReportedCntyserv:Not ReportedStateserv:SCZipserv:Not Reported

PWS ID: SC0860052

Date Initiated: 8407 Date Deactivated: Not Reported

PWS Name: CLOVERLEAF MHP LOUIS J DIMUZIO

PO BOX 31318 CHARLESTON, SC 29417

Addressee / Facility: Distribution Facility

LOUIS J DIMUZIO

OWNER PO BOX 31318

CHARLESTON, SC 29417

Facility Latitude: 32 51 42 Facility Longitude: 079 58 12

City Served: Not Reported

Treatment Class: Untreated Population: 00000085

Violations information not reported.

Map ID: 17

SC Epa region: 04 State: Pwsid: SC1070103 Pwsname: MCCLELLANVILLE LINCOLN (1070103) SC City served: Not Reported State served: Zip served: Not Reported Fips county: 45019 Status: Active Pop srvd: 385 Pwssvcconn: Source: Groundwater Pws type: **NTNCWS** Owner: State_Govt BROWN, KEITH Contact: BROWN, KEITH Contactor gname: 3999 BRIDGEVIEW DRIVE Contact phone: 843-566-1975 Contact address1: Contact address2: Not Reported Contact city: **CHARLESTON** Contact state: SC Contact zip: 29405-7485 Α Activity code: Location Information: MCCLELLANVILLE LINCOLN (1070103) Name: **NTNCWS** GW Pwstypcd: Primsrccd: Popserved: 385 Add1: 3999 BRIDGEVIEW DRIVE Add2: Not Reported CHARLESTON City: State: SC Phone: 29405-7485 843-566-1975 Zip: **MCCLELLANVILLE** Cntyserv: Charleston Cityserv: Stateserv: SC Zipserv: Not Reported PWS ID: SC1070103 Date Initiated: 7706 Date Deactivated: Not Reported MCCLELLANVILLE LINCOLN PWS Name: WILLIAM B SEARSON 2100 LEEDS AVENUE CHARLESTON HGTS, SC 29405 Addressee / Facility: Distribution Facility WILLIAM B SEARSON ASST DIR 2100 LEEDS AVE CHARLESTON HGTS, SC 29405 Facility Latitude: 32 51 24 Facility Longitude: 079 58 14 City Served: Not Reported Treatment Class: Untreated 00000455 Population: Violations information not reported. Map ID: 20 SC Epa region: 04 State: SC2570678 Pwsid: CAMP CHRISTIAN (2570678) Pwsname:

State served:

Fips county:

Pop srvd:

Source:

Owner:

City served:

Zip served:

Pws type:

Contact:

Pwssvcconn:

Contactor gname:

Status:

Not Reported

Not Reported

CAMP CHRISTIAN (SC2570678)

CAMP CHRISTIAN (SC2570678)

Closed

TNCWS

4

TC4663175.5w Page 51 of 53

SC 45049

24

Groundwater

Public/Private

Contact phone: 843-744-5786 Contact address1: 1293 ORANGE GROVE RD

Contact address2: Not Reported Contact city: CHARLESTON

Contact state: SC Contact zip: 29407

Activity code: N

Location Information:

Name: CAMP CHRISTIAN (2570678)

Pwstypcd: TNCWS Primsrccd: GW

Popserved: 24

Add1: 1293 ORANGE GROVE RD

Add2: Not Reported

City: CHARLESTON State: SC

Zip:29407Phone:843-744-5786Cityserv:Not ReportedCntyserv:HamptonStateserv:SCZipserv:Not Reported

PWS ID: SC2570678

Date Initiated: 8408 Date Deactivated: Not Reported

PWS Name: CAMP CHRISTIAN DAVID BROOKS

PO BOX 5246

NRTH CHARLESTON, SC 29406

Addressee / Facility: Distribution Facility

W KINARD OWNER PO BOX 5246

NRTH CHARLESTON, SC 29406

Facility Latitude: 32 51 15 Facility Longitude: 079 58 30

City Served: Not Reported

Treatment Class: Untreated Population: 00000060

PWS currently has or had major violation(s) or enforcement: YES

VIOLATIONS INFORMATION:

Violation ID: 9323440 Source ID: Not Reported PWS Phone: Not Reported Vio. beginning Date: 10/01/92 Vio. end Date: 12/31/92 Vio. Period: 003 Months

Num required Samples: Not Reported Number of Samples Taken: Not Reported Analysis Result: Not Reported Maximum Contaminant Level: Not Reported

Analysis Method: Not Reported

Violation Type: Monitoring, Routine Major (TCR)

Contaminant: COLIFORM (TCR)

Vio. Awareness Date: 012993

Violation ID: 9424097 Source ID: Not Reported PWS Phone: Not Reported Vio. beginning Date: 07/01/93 Vio. end Date: 09/30/93 Vio. Period: 003 Months

Num required Samples: Not Reported Number of Samples Taken: Not Reported Analysis Result: Not Reported Maximum Contaminant Level: Not Reported

Analysis Method: Not Reported

Violation Type: Monitoring, Routine Major (TCR)

42

Contaminant: COLIFORM (TCR)

Vio. Awareness Date: 101093

Map ID:

SC

Epa region: 04 State:

Pwsid: SC1070004
Pwsname: ESAU JENKINS

City served:Not ReportedState served:SCZip served:Not ReportedFips county:45019Status:ClosedPop srvd:55

Pwssvcconn:1Source:GroundwaterPws type:TNCWSOwner:Private

Contact: Not Reported
Contactor gname: Not Reported
Contact phone: 843-722-4112

Contact phone: 843-722-4112 Contact address1: LEON BURTON Contact address2: 51 NASSAU STREET Contact city: CHARLESTON

Contact state: SC Contact zip: 29403

Activity code:

Location Information:

Name: ESAU JENKINS

Pwstypcd: TNCWS Primsrccd: GW

Popserved: 55

Add1: LEON BURTON
Add2: 51 NASSAU STREET

City: CHARLESTON State: SC

Zip:29403Phone:843-722-4112Cityserv:Not ReportedCntyserv:Not ReportedStateserv:SCZipserv:Not Reported

PWS ID: SC1070004

Date Initiated: 7706 Date Deactivated: Not Reported

PWS Name: ESAU JENKINS

LEON L BURTON 51 NASSAU STREET CHARLESTON, SC 29403

Addressee / Facility: Distribution Facility

LINDA LYNCH EXEC DIRECTOR 5041 STORAGE ROAD YONGES ISLAND, SC 29449

Facility Latitude: 32 47 48 Facility Longitude: 079 57 06

City Served: Not Reported
Treatment Class: Untreated Population:

Violations information not reported.

FLORIDA GOVERNMENT WELL RECORDS SEARCHED

PWS: Public Water Systems

Source: EPA/Office of Drinking Water

Telephone: 202-564-3750

Public Water System data from the Federal Reporting Data System. A PWS is any water system which provides water to at

least 25 people for at least 60 days annually. PWSs provide water from wells, rivers and other sources.

PWS ENF: Public Water Systems Violation and Enforcement Data

Source: EPA/Office of Drinking Water

Telephone: 202-564-3750

Violation and Enforcement data for Public Water Systems from the Safe Drinking Water Information System (SDWIS) after

August 1995. Prior to August 1995, the data came from the Federal Reporting Data System (FRDS).

USGS Water Wells: USGS National Water Inventory System (NWIS)

This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on wells, springs, and other sources of groundwater.

State Wetlands Data: Wetlands Inventory

Source: Department of Environmental Protection

Telephone: 850-245-8238

Well Construction Permitting Database

Source: Northwest Florida Water Management District

Telephone: 850-539-5999

Consumptive Use Permit Well Database

Source: St. Johns River Water Management District

Telephone: 386-329-4841

Permitted Well Location Database

Source: South Florida Water Management District

Telephone: 561-682-6877

Super Act Program Well Data

This table consists of data relating to all privately and publicly owned potable wells investigated as part of

the SUPER Act program. The Florida Department of Health's SUPER Act Program (per Chapter 376.3071(4)(g),

Florida Statutes), was given authority to provide field and laboratory services, toxicological risk assessments,

investigations of drinking water contamination complaints and education of the public

Source: Department of Health Telephone: 850-245-4250

Water Well Location Information

Source: Suwannee River Water Management District

Telephone: 386-796-7211

Water Well Permit Database

Source: Southwest Water Management District

Telephone: 352-796-7211

DEP GWIS - Generalized Water Information System Well Data

Source: Department of Environmental Protection

Telephone: 850-245-8507

Data collected for the Watershed Monitoring Section of the Department of Environmental Protection.

DOH and DEP Historic Study of Private Wells

Source: Department of Environmental Protection

Telephone: 850-559-0901

Historic database for private supply wells.

Florida Sinkholes

Source: Department of Environmental Protection, Geological Survey

The sinkhole data was gathered by the Florida Sinkhole Research Institute, University of Florida.

Oil and Gas Permit Database

Source: Department of Environmental Protection

Telephone: 850-245-3194

Locations of all permitted wells in the state of Florida.

FLORIDA GOVERNMENT WELL RECORDS SEARCHED

STREET AND ADDRESS INFORMATION

© 2015 TomTom North America, Inc. All rights reserved. This material is proprietary and the subject of copyright protection and other intellectual property rights owned by or licensed to Tele Atlas North America, Inc. The use of this material is subject to the terms of a license agreement. You will be held liable for any unauthorized copying or disclosure of this material.

SOUTH CAROLINA GOVERNMENT WELL RECORDS SEARCHED

PWS: Public Water Systems

Source: EPA/Office of Drinking Water

Telephone: 202-564-3750

Public Water System data from the Federal Reporting Data System. A PWS is any water system which provides water to at

least 25 people for at least 60 days annually. PWSs provide water from wells, rivers and other sources.

PWS ENF: Public Water Systems Violation and Enforcement Data

Source: EPA/Office of Drinking Water

Telephone: 202-564-3750

Violation and Enforcement data for Public Water Systems from the Safe Drinking Water Information System (SDWIS) after

August 1995. Prior to August 1995, the data came from the Federal Reporting Data System (FRDS).

USGS Water Wells: USGS National Water Inventory System (NWIS)

This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on wells, springs, and other sources of groundwater.

State Wetlands Data: Wetlands Inventory Source: Department of Natural Resources

Telephone: 803-734-9494

Water Well Database

Source: Department of Natural Resources

Telephone: 803-734-6440

Water wells in the Coastal Plain counties of South Carolina

Water Well Database

Source: Department of Natural Resources

Telephone: 864-654-1671

A listing of water wells in the Piedmont (upstate) counties.

STREET AND ADDRESS INFORMATION

© 2015 TomTom North America, Inc. All rights reserved. This material is proprietary and the subject of copyright protection and other intellectual property rights owned by or licensed to Tele Atlas North America, Inc. The use of this material is subject to the terms of a license agreement. You will be held liable for any unauthorized copying or disclosure of this material.